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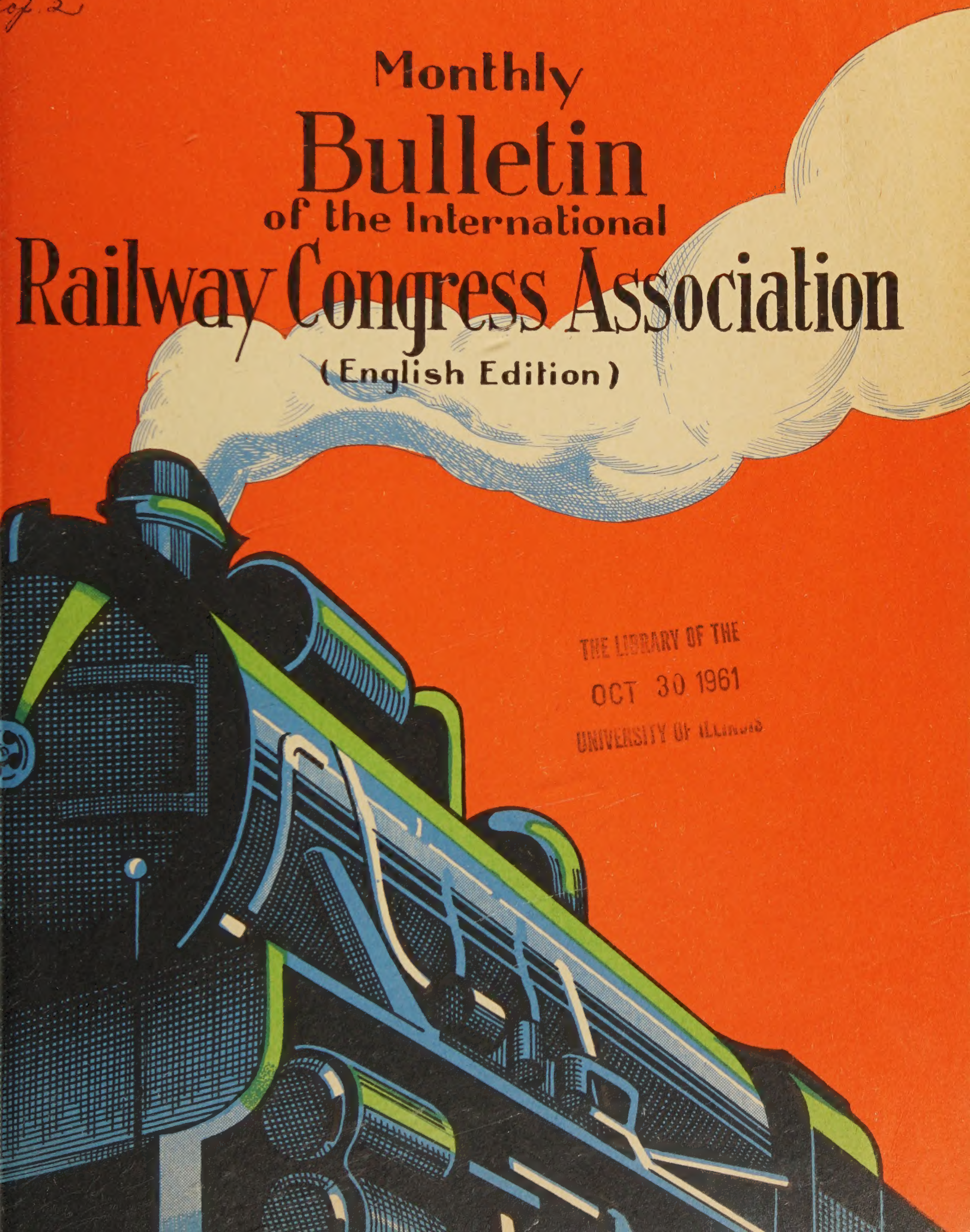
VOL. XXXVIII. — No. 9. SEPTEMBER 1961.

Monthly Bulletin of the International Railway Congress Association

(English Edition)



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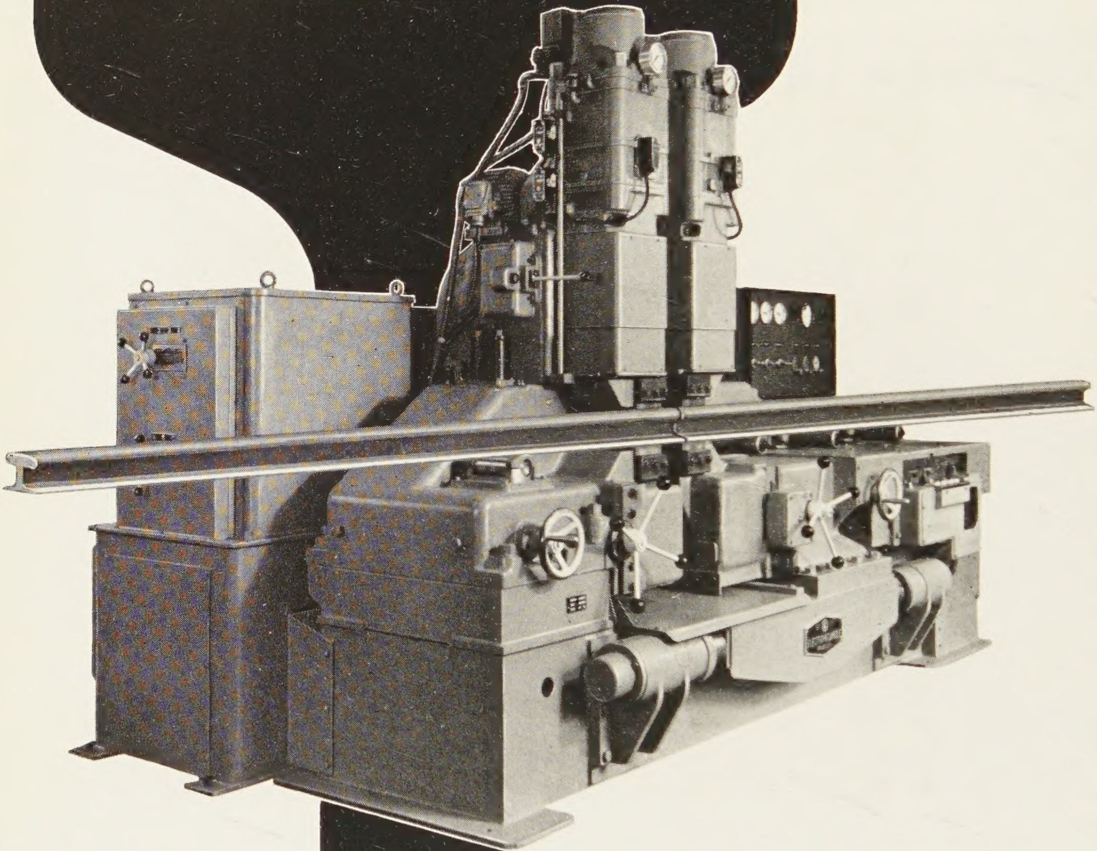

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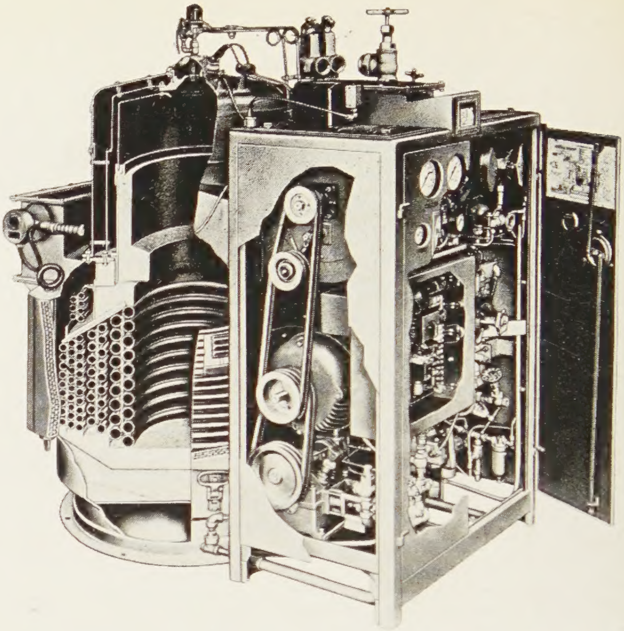

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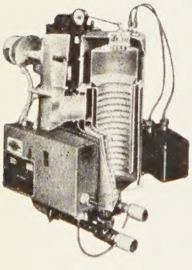

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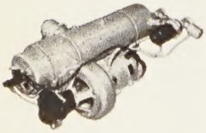

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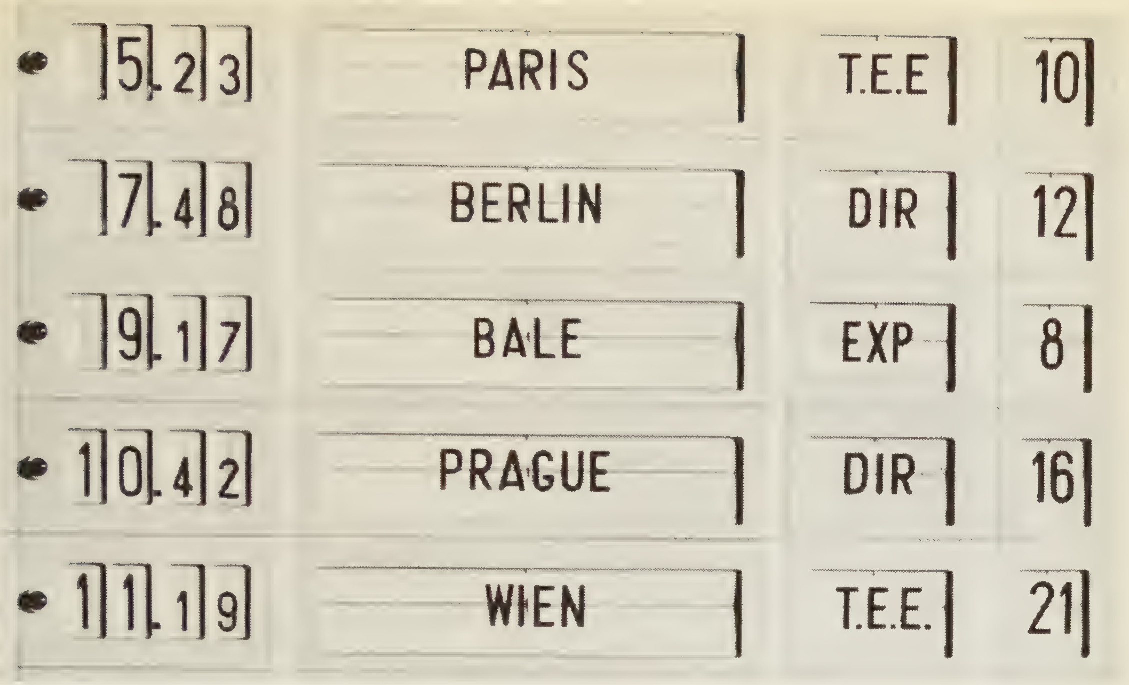

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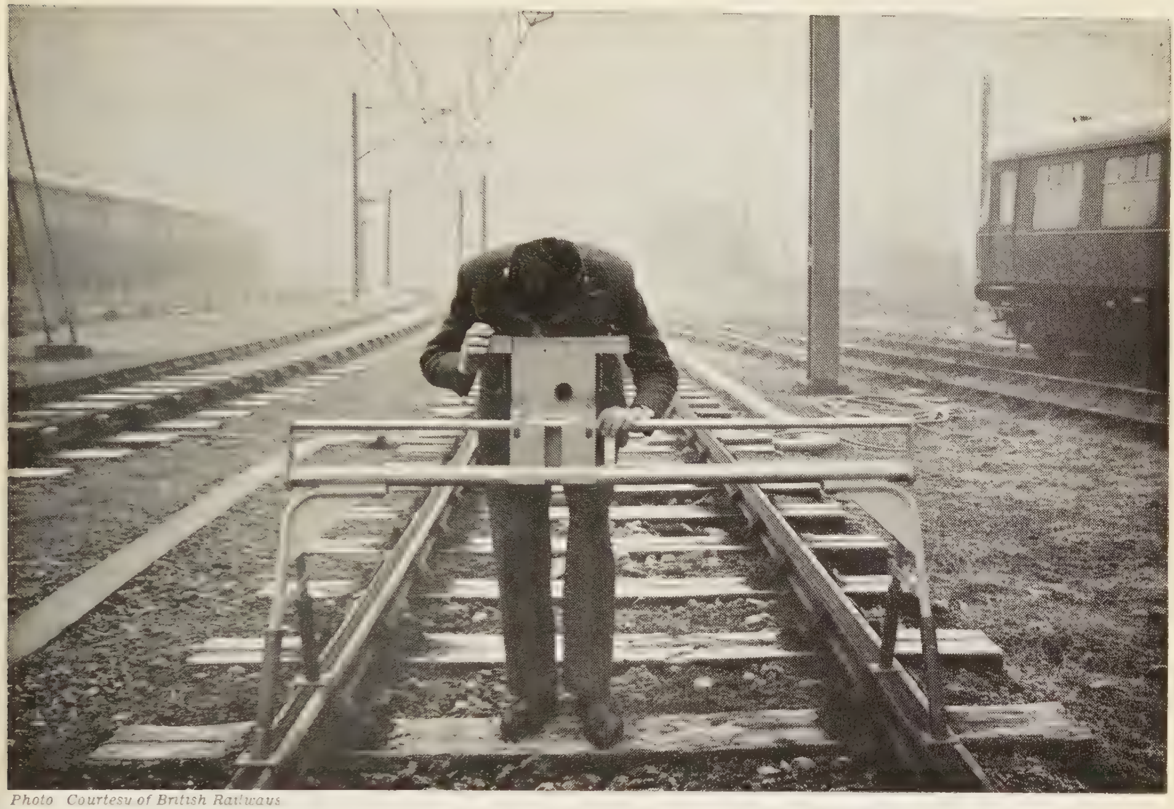

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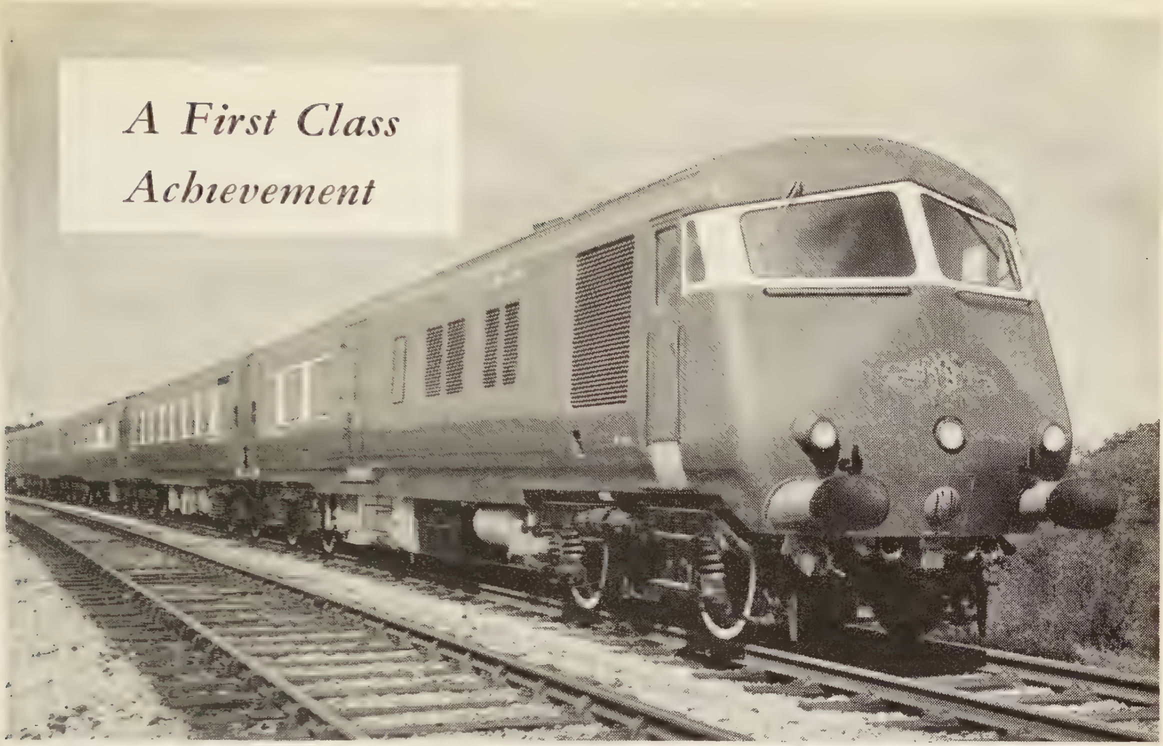

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MONTHLY BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS ASSOCIATION
(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

Price of this single copy : 80 Belgian Francs (not including postage).

Yearly subscription for 1961		
	Belgium	700 Belgian Francs
	Universal Postal Union	800 Belgian Francs

Subscriptions and orders for single copies to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau-Site, Brussels (Belgium).

Advertisements : All communications should be addressed to the Association, **19, rue du Beau-Site, Brussels (Telephone No. 47.53.35).**

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An edition in French is also published.

Vol. XXXVIII. — No. 9. September 1961.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .212 .9 (493)]

The mechanisation of exchange documents for goods wagons,

by P. Loumaye, Ingénieur en chef,

and R. Duchêne, Ingénieur,

à la Direction de l'Exploitation de la Société Nationale des Chemins de fer Belges.

Summary.

1. **Introduction.**
    - 1.1. International Convention for the transport of goods (C.I.M.).
    - 1.2. Regulations for the reciprocal user of wagons in international service (R.I.V.).
    - 1.3. Convention (Europ) for the common user of goods wagons.
    - 1.4. The part played by Montzen station in international exchanges.
2. **Former method of preparing the exchange papers.**
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4. **Equipment used.**
    - 4.1. Radio equipment.
    - 4.2. Trials of magnetic recording.
    - 4.3. Lighting.
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5. **Analysis of the train sheets.**
6. **Checking the correctness of telegraphical transmissions.**
    - 6.1. Checking the total errors.
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7. **Conclusions.**
    - 7.1. Quality of the work.
    - 7.2. Saving in labour.
    - 7.3. Working conditions for the staff.

1. Introduction.

1.1. *The International Convention for the transport of goods (C.I.M.).*

According to the terms of the « International Convention for the transport of goods » (C.I.M.), every railway administration is obliged to accept, under certain conditions, goods to or from other countries or in transit.

The original Convention was signed at Berne in 1890, and made obligatory in Belgium by a law of the 25th March 1891. Revised regularly, the terms now in force date from 1952, and bind the Railway Administrations of some 20 European countries.

The C.I.M. has set up a Central Office for International Transport by Rail, at Berne, in order to assure the carrying out of the C.I.M., and in particular to facilitate the financial relations between the member Administrations.

1.2. *The regulations for the reciprocal user of wagons in international service (R.I.V.).*

The C.I.M. is essentially concerned with the actual transport of goods : it says nothing about the rolling stock itself, in particular its admission and use on the lines of another railway than the railway owning it.

The Railway Administrations have, for a long time, made agreements amongst themselves on this subject, first of all bilateral ones, and latterly multilateral.

As they were considered insufficient, these agreements were replaced in 1921 by a general regulation : the « Regulations for the reciprocal user of wagons in international service » (R.I.V.) (¹), which, in its present form (Pau edition 1958) binds 27 Administrations in 20 countries, i.e. practically all the standard gauge European railways.

The prescriptions of R.I.V. concern mainly :

— the technical conditions that the wagons must satisfy to be accepted, as well as loading conditions;

— the rules to be followed in routing the wagons on the return run, loaded or empty, and the payments to which the railways are entitled, under the heading of their user, from foreign railways.

Wagons represent a very costly capital investment (²), and it is of the greatest importance that they should have the maximum possible user.

It is therefore necessary that the turnround, i.e. the time between two successive loadings of wagons is reduced to the minimum (³).

As regards the conditions under which the rolling stock is to be used, the R.I.V. is based on the following two fundamental rules :

1) the Administrations owning the wagons are paid for their use by other railways, since these latter get the corresponding traffic receipts;

2) wagons which have been used for international transport must, after being unloaded, be returned in the shortest possible period to their own railway.

These rules are translated in practice :

a) by a hire payment of 5 gold francs per wagon-day (6 gold francs after the 16th day) to the owner railway;

b) by the obligation to send back the wagons :

— if they are reloaded, to their own railway, in the direction of their own railway or beyond;

— if they are empty, to their own railway, by the same route as on the outward run.

As a result of these stipulations, each Administration which is a member of R.I.V. has to keep a record of the time each foreign wagon remains on its sys-

---

(¹) R. I. V. = Regolamento Internazionale Veicoli.

(²) At the present time a wagon costs on the average 300 000 francs.

(³) If the turn round is designated by R (days), the number of wagons by E and the daily number of wagons loaded by C, we get $E = R \times C$.

tem; in order to be able to check the amounts due from other railways to it, it also has to keep a record of the departure and return of its own wagons at the various exchange stations.

1.3. *Convention (EUROP) for the common user of goods wagons.*

In 1953, at the instance of the S.N.C.F. and the D.B., there was concluded between some of the Administrations belonging to R.I.V., for the purpose of reducing the mileage of empty wagons between railways, a « *Convention for the common user of goods wagons* » generally known under the name of « *Convention Europ* ».

At the present time, 9 railways belong to this. They have set up, at Berne, an Office responsible for the working of the Convention. The stock includes a large number of covered wagons and open wagons of the most recent types, to a total of some 200 000 wagons, 21 500 of which belong to Belgium.

According to the Convention « EUROP », each member railway can use EUROP wagons belonging to other Administrations as though they were its own.

The only condition is that the number of EUROP wagons allocated to it does not exceed its contribution to the common stock.

When a railway has too many wagons, the EUROP office lays down the traffic movements intended to restore equilibrium.

The daily surplus of each railway obliges it, as for the R.I.V. regime, to pay a fee to the railways with a shortage : at the present time this payment is 4.25 gold francs per open wagon and 4.75 gold francs per covered wagon, but in certain cases it may be increased to 10 gold francs.

It is also the EUROP Office which makes out the reciprocal accounts for each railway, by means of the statements it receives daily, concerning the number of wagons exchanged as well as a statement of costs due to the use of spare parts needed to repair damaged wagons.

It results from what has been said above, that the exchange stations have to keep a record, as for the R.I.V. wagons, but quite separately, of the entry and departure of all the EUROP wagons.

1.4. *The part played by Montzen station in international exchanges.*

Belgium is only a small country but it has a very advantageous geographical position : it is therefore in no way astonishing to find that about three quarters of its railway traffic, expressed in tonnes-kilometres, consist of goods being exported, imported, or in transit.

To assure this traffic, there are a great many frontier stations, the most important of which are : Essen and Visé in the direction of Holland, Montzen in the direction of Germany, Gouvy and Stockem in the direction of Luxemburg, Athus in the direction of Luxemburg and France, and Lamorteau and Erquelinnes in the direction of France (fig. 1).

The number of wagons exchanged with neighbouring railways is of the order of 210 000 a month, with 52 000 for Montzen station alone.

The neighbouring stations of the Deutsche Bundesbahn (D.B.) are Aachen (West) and Aachen (South), whereas towards the interior of the country, Montzen is connected to the main marshalling yards and with Erquelinnes, an important frontier station to France.

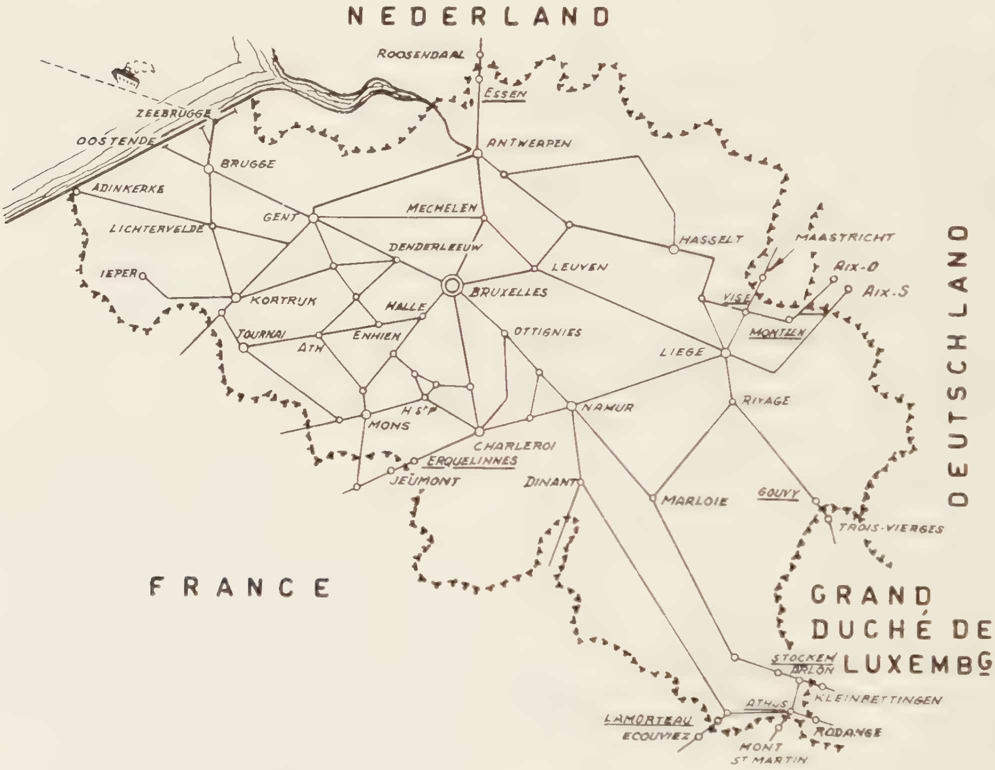

Fig. 1. — Map showing the main international lines running through Belgium.

Figure 2 shows diagrammatically the installations of Montzen station which consist essentially of :

— a reception set of sidings A and a set B for the Germany-Belgium direction;

— a single set D for the Belgium-Germany direction;

— a goods shed E;

— a locomotive depot L.

The plan also shows :

— at I, the goods office;

— at II, the assistant station master's office, who is responsible for marshalling A B;

— at III, the main collection office.

The traffic at Montzen at the present time amounts to 2 500 wagons a day.

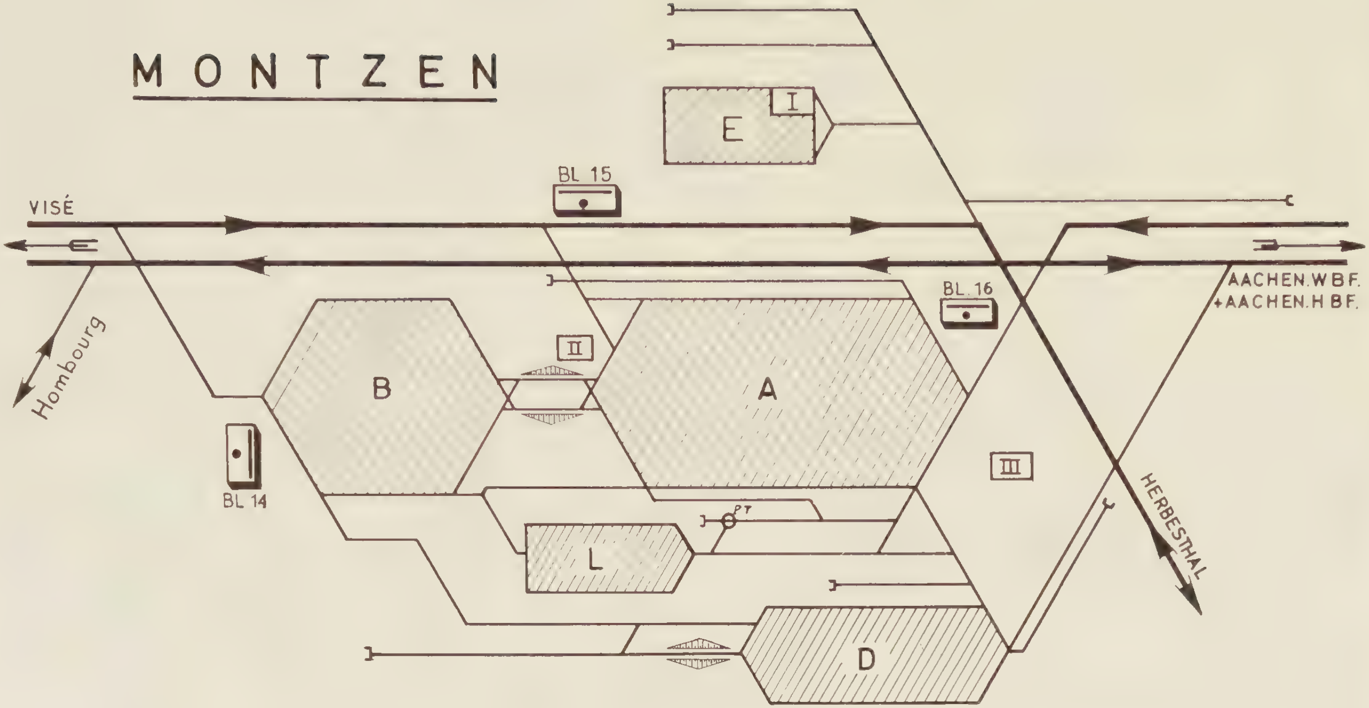

Fig. 2. — Diagram of the installations at Montzen Station.

Legend :

A B D = siding sets A B D.
L = locomotive shed.
E = warehouse.

I = warehouse or bounded goods office.
II = office of marshalling superintendent
III = main collecting office.

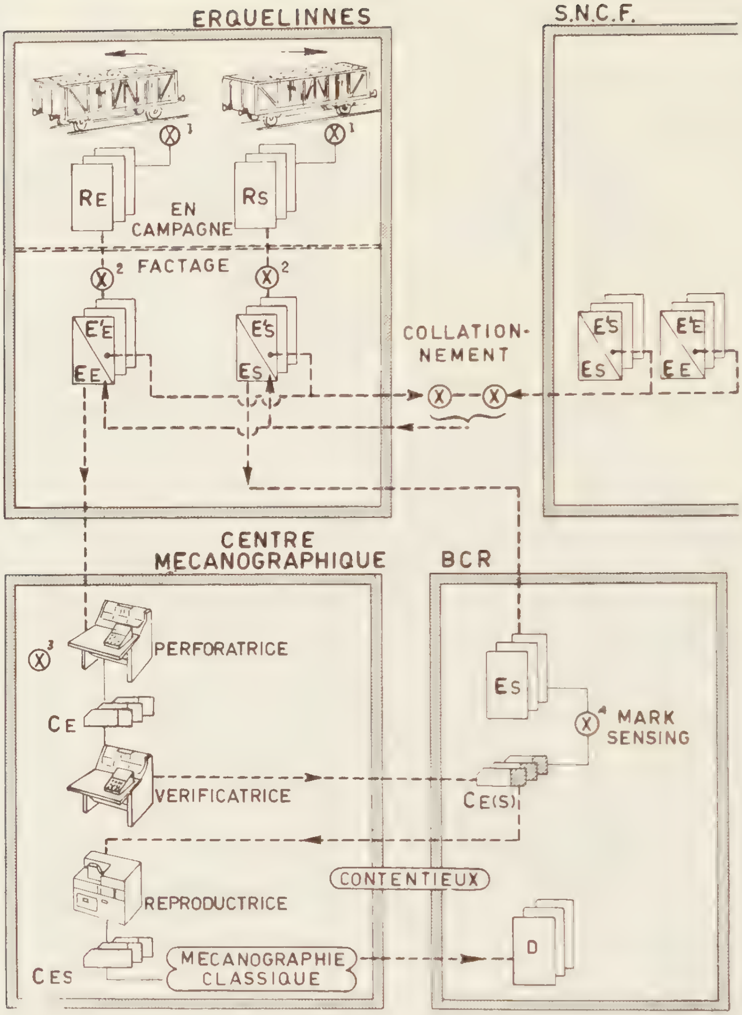

Fig. 3. — Diagram of the old method of preparing the exchange documents.

Legend :

BCR = Central Allocation Office of the Operating Department.

⊗ = operation likely to introduce errors in the documents.
1. Preparing the train statement.
2. Preparing the exchange documents.
3. Perforating the entry cards.
4. Marking the entry cards (mark sensing).

R_E R_S = train statements on entering or leaving.
E'_E E'_S = exchange documents for the train on entering or leaving.
E_E E_S = collated and corrected exchange documents.
C_E = mechanographical cards, with perforations relating to train entering.
$C_{E(S)}$ = the same as C_E with in addition, indications for mark sensing on departure.
C_{ES} = mechanographical card with perforations relating to entry and departure of the same wagon.
D = statement of accounts between Administrations.

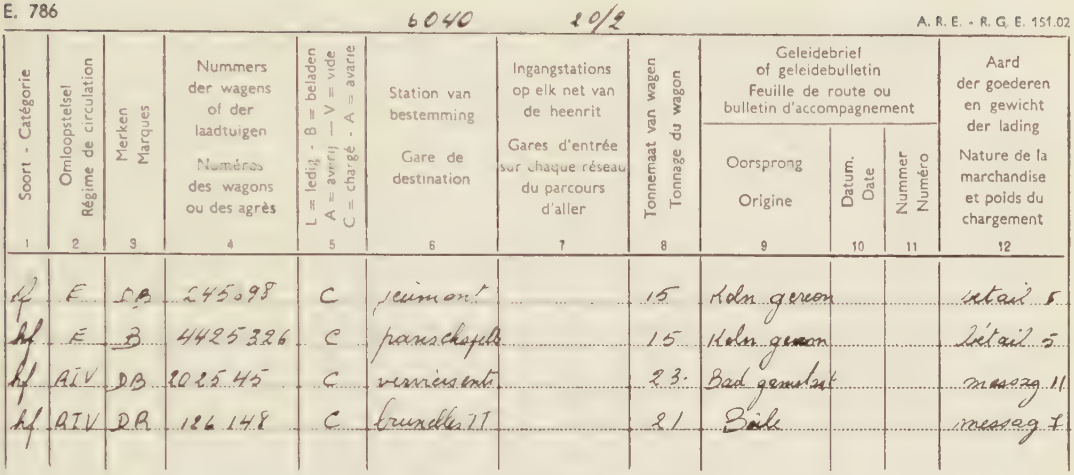

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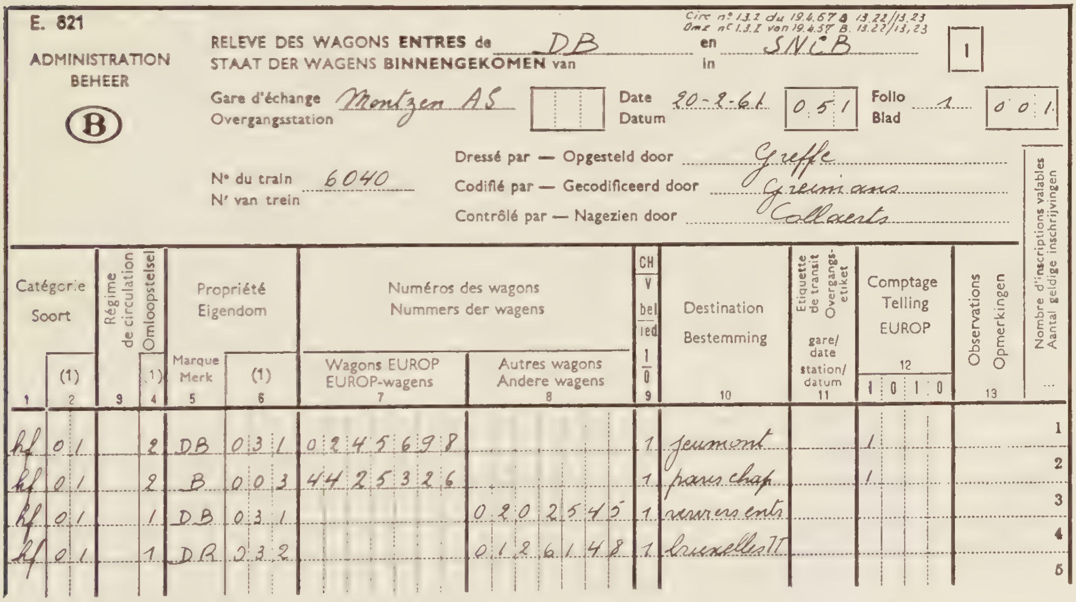
Fig. 4. — Train statement.



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Circ nº 13.2 du 19.4.57 B. 13.22/13.23
Omz nº 13.2 van 19.4.57 B. 13.22/13.23

RELEVE DES WAGONS **ENTRES** de DB en SNCB
STAAT DER WAGENS **BINNENGEKOMEN** van in

1

Gare d'échange — Overgangsstation: Montzen AS

Date — Datum: 20-2-61 | 0 5 1

Folio — Blad: 1 | 0 0 1

Nº du train — Nº van trein: 6040

Dressé par — Opgesteld door: Greffe

Codifié par — Gecodificeerd door: Greimans

Contrôlé par — Nagezien door: Collaerts

Catégorie Soort 1	(1) 2	Régime de circulation 3	Omloopstelsel (1) 4	Propriété Eigendom: Marque Merk 5	(1) 6	Numéros des wagons Nummers der wagens: Wagons EUROP EUROP-wagens 7	Autres wagons Andere wagens 8	CH V bel/led 1/0 9	Destination Bestemming 10	Etiquette de transit Overgangs-etiket gare/date station/datum 11	Comptage Telling EUROP 12 1 0 1 0	Observations Opmerkingen 13	Nombre d'inscriptions valables Aantal geldige inschrijvingen ...
hf	01		2	DB	031	0245698		1	jeumont		1		1
hf	01		2	B	003	4425326		1	pans chap.		1		2
hf	01		1	DB	031		0202545	1	verviers ent.				3
hf	01		1	DR	032		0126148	1	bruxelles TT				4
													5

Fig. 5. — Exchange document.

2. The old method of preparing the exchange documents.

Figure 3 shows in diagram form the old method of preparing the exchange documents used in the frontier stations of the S.N.C.B., such as Erquelinnes for example.

As soon as a train arrives from

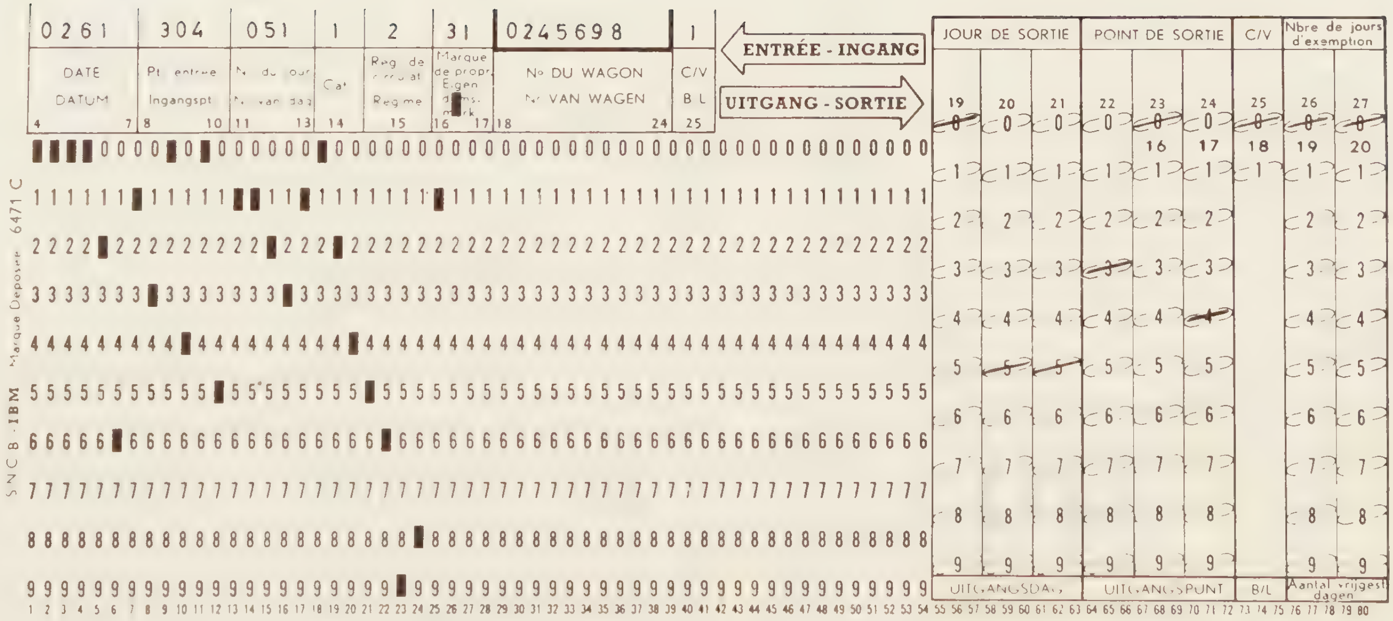


Fig. 6. — Perforated card (Entry - Departure).

The indications corresponding to the entry of the wagon are written in the ordinary way and by means of perforations in the left hand side of the card. The right hand side of the card has already received the mark sensing indications.

France, one of the clerks walks along the train and draws up a *train statement* RE (fig. 4), showing the main characteristics of each wagon, both empty and loaded.

The train statement is then compared in the collection office with the transport documents and used as the basis for an *exchange document* E'E with a numerical code (fig. 5).

These same operations are also carried out before a train leaves for France (documents Rs and E's).

The French exchange station (Jeumont) proceeds in a similar manner both on arrival and departure.

Every day the *exchange documents* of the trains of the previous day are compared by employees of the two Administrations, alternatively in Belgium and in France and the documents adjusted (documents EE and Es).

The adjusted exchange documents EE for trains coming in are sent to the Mechanographical Centre of the Department, at Brussels; they are reproduced, wagon by wagon, onto perforated cards CE (fig. 6) (this operation is checked by a verifying machine) which are then sent, arranged in numerical order, to the Central Allocation Office of the Operating Department (BCR).

The exchange documents for trains going out, on their side, are sent directly to BCR.

The BCR is thus in possession of mechanographical cards for trains coming in CE and exchange documents for trains going out Es from all the exchange stations on the system.

The mechanographical cards CE show, on the left hand side, data concerning the entry of the wagons to the railway; they have to be completed, on the right hand side, by data concerning their departure.

This operation is done at the BCR by comparing the CE cards of the exchange documents Es by the « mark sensing » process, i.e. by marking with a special pencil the appropriate indications corresponding to the supplementary spaces to be perforated.

The work of the BCR is lengthy and fastidious, since it is a question, for each of the some 4 000 wagons which leave the railway every day, of finding its entry card; a well trained employee may succeed in dealing with some 1 000 wagons a day.

Cards that have been treated with the mark sensing process are sent back to the Mechanographical Centre where they pass through a machine of the mark sensing reproducer type, i.e. they are read electrically and automatically perforated in the proper spaces (CEs).

The Mechanographical Centre is thus finally in possession of all the data needed for calculating the amounts due for each foreign wagon which has run on the S.N.C.B. system, and to check the accounts of foreign railways in connection with Belgian wagons.

We will not go into details about the mechanographical operations required (passing the cards through sorters, computers, tabulators, etc.).

3. **New method**
of preparing the exchange documents.

Figure 2 shows in diagram form the new method introduced at Montzen on the 1st October 1959, for preparing ex-

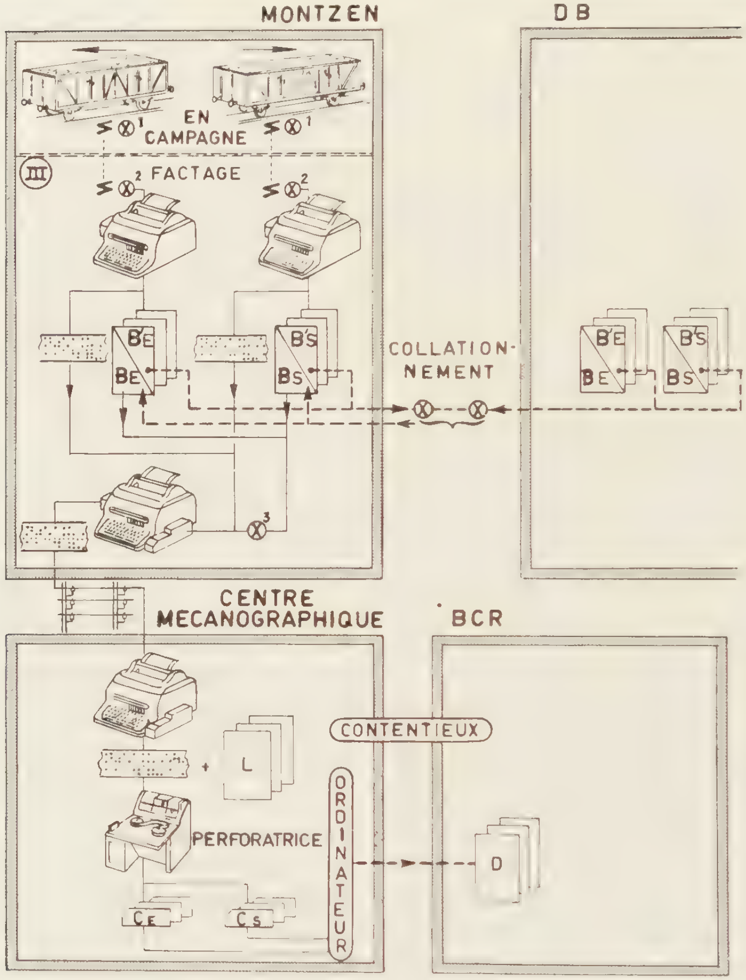


Fig. 7. — Diagram of the new method of preparing the exchange documents.

Legend :

BCR = Central Allocation Office of the Operating Department.

Z ·· Z = radio transmission.

⊗ = operation likely to introduce errors in the statements.
1. Reading off and transmitting the wagon characteristics.
2. Preparing the train statement from what is heard.
3. Correcting the telegraphic strips after they have been collated.

B'_E B'_S = train statement on entry or departure.

B_E B_S = train statement collated and corrected.

C_E C_S = mechanographical entry or departure cards.

D = statement of account between Administrations.

L = exchange listings.

change documents with the Deutsche Bundesbahn.

As soon as a train from Germany comes in, or on leaving Belgium, as soon as the marshalling operations are completed, a clerk equipped with a radio transmitter-receiver set (fig. 8) goes to the train.

As he walks along it, he transmits the characteristics of each wagon to a colleague with a similar radio set, who is sitting in front of a teleprinter (fig. 9) in the main collecting office (point III of fig. 2).

The office employee records the information he gets and thus makes up the *train statement* B'E (or B's), which replaces both the train statement and the exchange document of the old method, at the same time as a perforated telegraphic strip (fig. 14).

In the case of trains leaving for Germany, a copy of the train statement is used as the statement travelling with the transport documents.

The collating of the train statements with the German services takes place, as in the case of the old method, on the following day; in the near future, it will also be possible to do this collating on a machine which compares the strips, using the telegraphic strips of the two railways, the arrangement and codification of the statements naturally being identical.

In this way, the final statements BE (or Bs) are obtained and corrected strips, which are transmitted by tele-

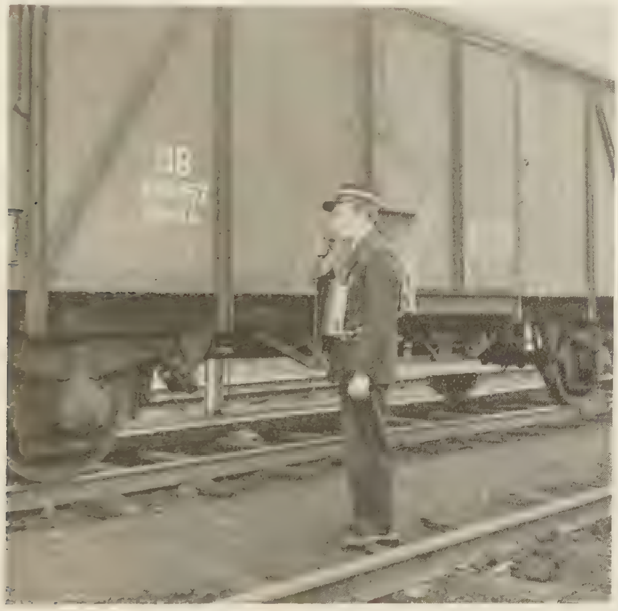


Fig. 8. — A station clerk transmitting by radio the characteristics of a wagon.

graph to the Mechanographical Centre of the Department where they are received on teleprinters in the form of *exchange listing* L and strips.

The latter are placed in a strip perforator-translator which makes up for each wagon coming in (or leaving) a separate mechanographical card (fig. 10).

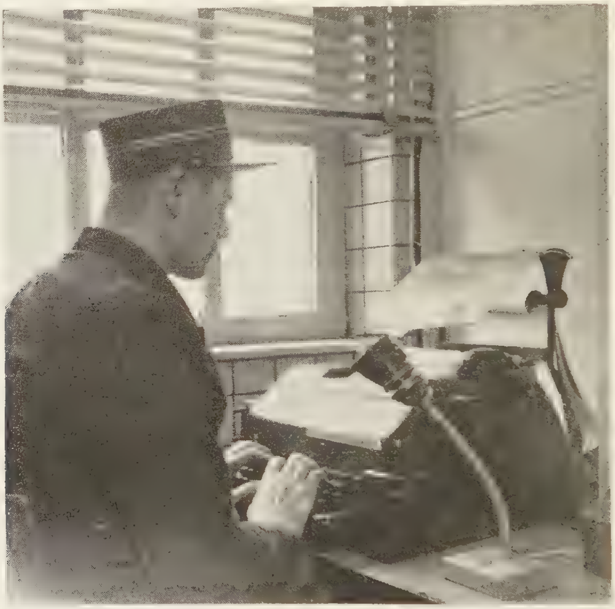


Fig. 9. — A station clerk receiving by radio the characteristics of a wagon and making out the train statement from what he hears.

The mechanographical cards are automatically checked, then dealt with by an ordinator which prepares the statements of account.

4. **Equipment used.**

4.1. *Radio equipment.*

The portable transmitter-receiver set (fig. 8) is in the form of two separate cases with a total weight of 6 kg, joined together by straps. The front case contains the transmitter-receiver properly speaking, whilst the back case holds the low tension batteries and the other supply arrangements.

The microphone is of the « dynamic » type and also acts as a loudspeaker; it is fitted with a transmission-reception switch and can be either fixed rigidly on the case, or connected to it by a flexible cable.

A whip antenna (± $\lambda/8$) is fitted on the case and a switch allows of a choice of one of the 6 channels available (between 32 and 33 Mc).

So that the employee knows how much charge there is, the battery case

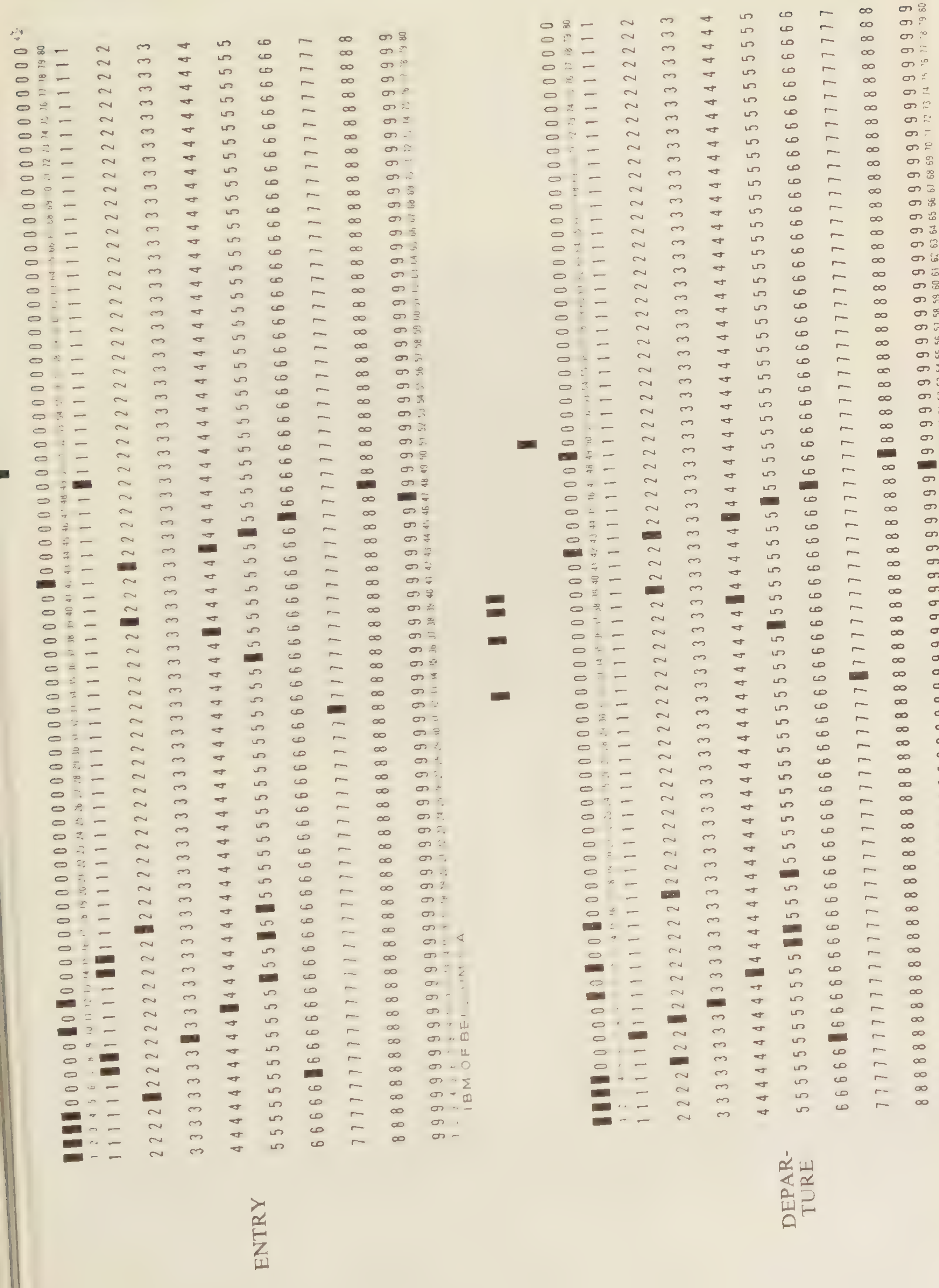


Fig. 10. — Perforated cards (Entry - Departure). This refers to the same wagon as fig. 6.

is fitted with windows; each cell contains three small coloured balls which float on top when the cell is fully charged, and drop down as it becomes discharged. The batteries are recharged as soon as 2 balls have dropped.

The clerk in the office is in a sound-proofed cabin in the main office (point III).

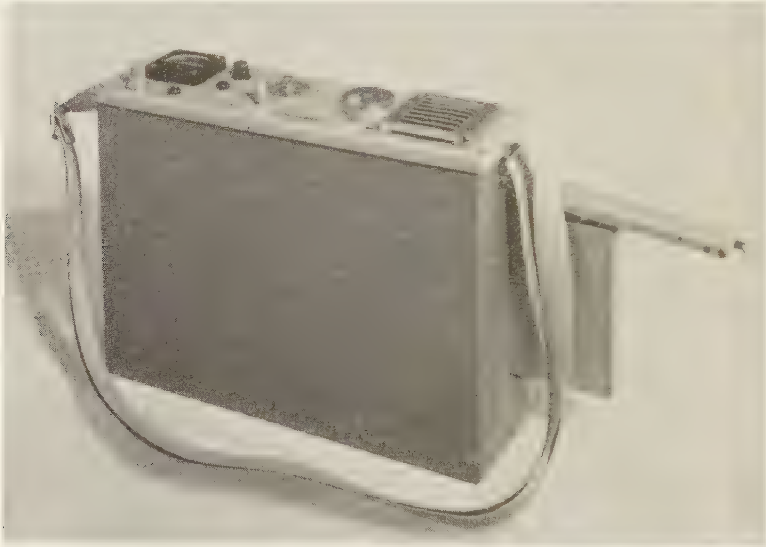


Fig. 11. — Portable magnetophone.

He can receive directly through loudspeaker, or amplified, or through headphones; the staff generally prefer to listen through headphones.

4.2. *Trials of magnetic recording.*

A great many stations, where the traffic is between 500 and 1 000 wagons exchanged a day, do not have enough staff to work in the above fashion, and equipment of this size is not justified (100 000 francs for each two-way radio post).

Consequently, trials were carried out of recording by means of magnetophone.

With this method, the clerk on the site records the wagon characteristics as in the above method, but they are recorded on a magnetophone which he is using, in the listening position, to prepare the train statement on the teleprinter.

After trying out the first equipment which did not give satisfaction, a new prototype will shortly be tried at Visé station.

The characteristics of this apparatus are as follows (fig. 11) :

— the magnetic strip and its coil are enclosed in a case so that no delicate adjustment is needed to engage them with the magnetophone or release them;

— the positive indication of the recording is given by an indicator of the level of modulation with a movable point;

— the batteries can be recharged without removing the equipment, the condition of the batteries being revealed by the indicator of the level of modulation;

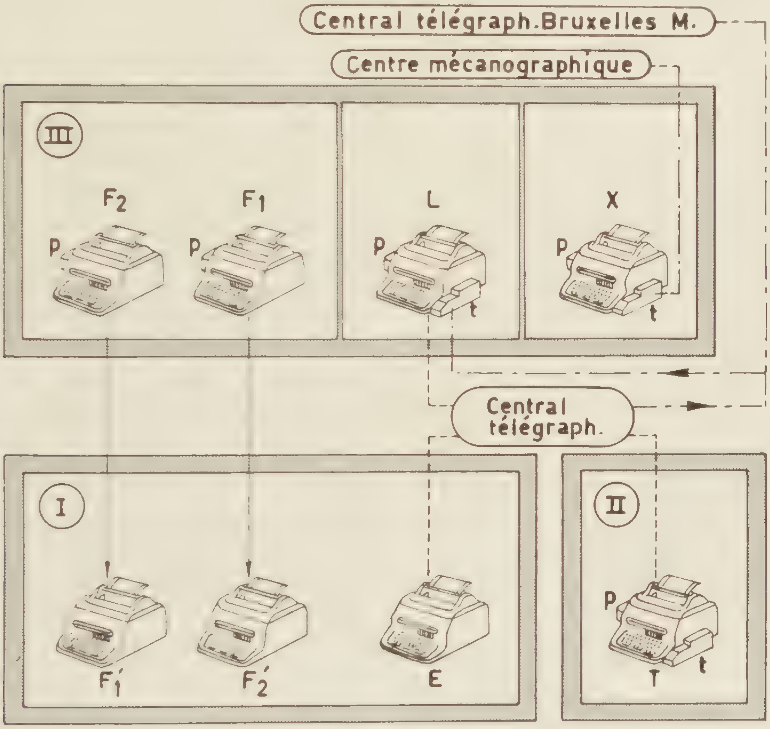


Fig. 12. — Teleprinter relations.

— a microphone is fixed to the apparatus, but there is also a connection for an outside microphone;

— the whole duration of a recording is about 40 min, which is quite sufficient for the longest trains;

— the weight of the apparatus does not exceed 3 kg.

4.3. *Lighting.*

To facilitate the work of the clerks on the site, they are equipped with a head light supplied from an accumulator of the cadmium-nickel type, which does not require any special maintenance.

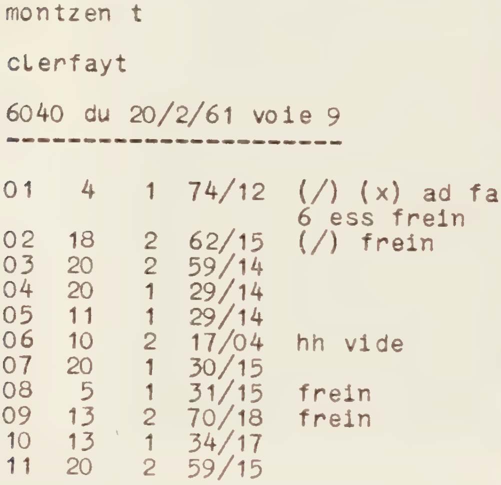
With magnetic recording as described above, the head light can be supplied from the recorder battery.

4.4. *Teleprinters.*

The teleprinters used for the exchange documents are of the usual type.

Figure 12 shows in diagram form the services with which the 8 sets in use at Montzen are concerned.

a) Teleprinters F1 and F2 of the collection office (point III) are used for making out the train statements, and are connected directly to the teleprinters F'1 and F'2 in the goods office (point I) the customs officers are thus able to communicate, without loss of time, customs demands for certain wagons, such as : transfer to the warehouse, marshalling on a special siding, etc.



```
montzen t

clerfayt

6040 du 20/2/61 voie 9
----------------------

01    4   1  74/12  (/) (x) ad fa
                    6 ess frein
02   18   2  62/15  (/) frein
03   20   2  59/14
04   20   1  29/14
05   11   1  29/14
06   10   2  17/04  hh vide
07   20   1  30/15
08    5   1  31/15  frein
09   13   2  70/18  frein
10   13   1  34/17
11   20   2  59/15
```

Fig. 13. — Shunting statement.

The first column is the number of each cut.

The second column is the number of the shunting siding.

The third column is the number of wagons per cut.

The fourth column indicates the total weight of the cut and the first axle load.

Special indications can be shown as regards the braking, kind of load, etc.

Teleprinters F1 and F2 are fitted with strip perforators which can be cut out (sign +) or switched in (sign :).

In this way, the perforated strips intended for making at the Mechanographical Centre, the lists and separate perforated cards (entry, departure) only show the data required for making up the accounts.

The transmission of the strips is done by teleprinter X.

b) Teleprinter E in the warehouse office is connected to the teleprinter T in the marshalling post (point II) by means of the station telephone exchange.

It is used for transmitting the marshalling lists (fig. 13) which can be prepared as soon as the customs officials have seen the train statement and communicated their decisions regarding it.

Teleprinter T is fitted with a strip perforator, which enables it to recopy the marshalling lists very rapidly making as many copies as are required.

c) Teleprinter L is in general use.

4.5. *Classifying the perforated strips.*

The perforated strips average 4 m in length per train : an arrangement for classifying the original strips has been provided as well as a device for rolling them up quickly. A capacity for classifying ten days strips has been provided.

5. **Analysis of the train statement.**

We think it of interest to give a brief analysis of the data on the train statement part of which is reproduced in figure 14.

It is divided into four parts, viz. :

a) a *heading « station classification »*.

Montzen

2/16 « greffe » greismans :

which data only concern Montzen station itself and are not intended to be retransmitted; such as the name of the station, number of the teleprinter, a series order number of the statement, and the name of the employees concerned;

b) a *heading « train »:*

= = 1 304 051 (006040) 1525 + track 09 a q :

```
montzen

2/16 greffe greismans :
---------------
==1 304 051 (006040) 1525+voie 09 a q :
,,,,,,,,,,,,,,,
:g   e db  0245698(2 10 15)1+11 1 koln gereon jeumont rec   :
:g   e b   4425326(2 10 15)1+13 0 koln gereon paris chapelle rec :
:g   r db  0202545(2 12 23)1+19 0 bad gammstatt verviers ent (/) :
:g   r dr  0126148(2 14 21)1+21 1 bale bruxelles tt          (/) :
:g   r db  0205110(2 12 16)1+13 1 bale ostende rec          :
:g   r b   1054778(2 10 21)1+10 0 kulstein londres rec      :
:g   e fs  1162751(2 12 34)1+22 0 salzburg hoboken rec      :
```

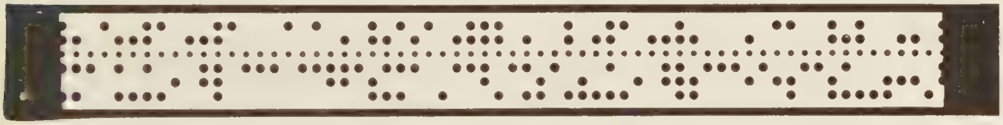


Fig. 14. — Train statement and perforated strip.

This heading begins with the double sign = = intended to unlock in the strip perforator-translator a device causing the perforations, to be made on all the cards, of the text between this sign and the following + sign, with the exception of the text in parentheses.

This first part includes the data relating to the exchange papers; the second part, beyond the + sign, is intended for the station traffic department and is not reproduced on the perforated strip.

The heading « train » signifies in actual fact :

1	train in the Germany to Belgium direction (2 = Belgium-Germany direction);
304	route Montzen-Aachen South; (305 = route Montzen-Aachen West);

051	order number of the day counting from the 1st Jan. (= 20th Feb.);
006040	train number;
1525	time of arrival (departure) essential;

track 09 a	set A, track 9;
q	statement made starting at rear of train (t = statement made starting at head of train).

c) the main part of the statement :

: g c db 0245698(2 10 15) + 11 1 koln gereon jeumont rec :

. . . .

The main part of the statement consists of one line per wagon divided into two parts which are separated by a + sign, which has the same meaning as above.

g	category of wagon according to UIC Note No. 438 (e and f would designate open wagons, g, h and i covered wagons, etc.);
e	type of service : e = EUROP; r = RIV; p = private wagon, etc.;
db	mark of ownership; the first three letters of the mark painted on the wagon are given : db = D.B.; b = S.N.C.B.; snc = S.N.C.F., etc.;
0245698	wagon number;
2	number of axles;
10	tare;
15	total weight;
1	loaded wagon (0 = empty wagon);
11	brake weight;
1	wagon fitted with hand brake (0 = wagon without brake);
koln gereon	departure station;
jeumont	arrival station;
rec	special indication (registered wagons, fragile, for quick delivery, etc.).

d) the end of the statement.

- - - - - - - - - - - - +

This is shown by a series of dots -, followed by the + sign which puts the perforator out of action for the following statement.

6. Checking the correctness of the telegraphic transmission.

At the present time, the telegraphic transmission of the perforated strips between Montzen station and the Mechanographical Centre of the Management is still duplicated by sending the strips themselves, but it is obvious that the object to be aimed at is to do away with this.

To do so, it will be necessary to be satisfied that the telegraphic transmission is accurate.

To ascertain whether this is so, trials have been organised, taking as the basic element the perforated strip produced by teleprinter X at Montzen.

Mistakes can be divided into 4 categories, viz. :

a) mistakes in reading strip A at Montzen;

b) mistakes introduced during transmission between Montzen and Brussels;

c) mistakes in making out strip B by the teleprinter at the Mechanographic Centre;

d) mistakes in translating strip B into card C.

6.1. *Checking the total errors.*

To reveal the total sum of errors *a*) to *d*), it is only necessary to compare the cards C with the strip A sent by train.

This test is carried out by means of a verifying machine.

6.2. *Checking the actual transmission.*

The telegraphic strips used make use of a 5 moment perforation code, i.e. for each sign to be transmitted there are 1 to 5 perforations to be selected on 5 tracks; the total number of signs amounts to 56 including the interline signs, return of carrier, spacings, etc., as well as the two signs selecting the series of letters and the series of figures, and other characters.

In another code with 7 moments, each sign to be transmitted always has 3 perforated tracks and 4 non-perforated tracks; with this system, on reception a check is made whether the sign is properly made up of 3 perforations only, and if not, a special signal is sent back to the transmitting post which retransmits the sign, put on record, if necessary several times until a correct sign is received, i.e. with 3 perforations.

The probability of a sign with 3 perforations being received which is not the same as the sign transmitted is very small, since this would mean that the appearance of a parasitic perforation coinciding with the disappearance of the perforation that should have appeared.

Checking errors in transmission on these lines necessitates the following equipment :

a) equipment for reading off strip A at Montzen;

b) equipment translating the code (from 5 to 7 moments);

c) an automatic error counter.

Equipment *a*) to *c*) is shown on the left of figure 15;

d) the 4 line transmission from Montzen to the Mechanographical Centre;

e) a 7 moment receiving apparatus;

f) apparatus for translating the code (from 7 moments to 5 moments);

g) a teleprinter.

6.3. *Result of the check tests.*

Over a period of 4 months, covering the transmission of more than 2 300 000 signs, the error counter for Montzen only recorded 23 transmission mistakes, i.e. 23 cases in which the sign transmitted was referred back to Montzen by the Mechanographical Centre, i.e. 1 error per 100 000 signs.

In addition the comparison between the strip A and the cards C revealed 19 errors, which had nothing to do with the transmission, caused by the translating equipment at Montzen, by the teleprinter, or due to the way the cards were perforated.

Of these 19 errors, 14 could not fail to be noticed, owing to the actual make up of the train statements; these in effect never show any letter at certain places, and in other places no figures, whilst in certain columns the signs which can appear must be one of a small group, etc.

If the same proportion is allowed as for mistakes in transmission, it may be stated that out of 42 errors, only 11 were not discovered by the Mechanographical Centre, and would therefore have resulted in further investigations.

This proportion of 1 error per 210 000 signs, i.e. 1 error per 5 500 wagons, is completely acceptable, and in any case very much below the proportion of errors which occurred with the old method.

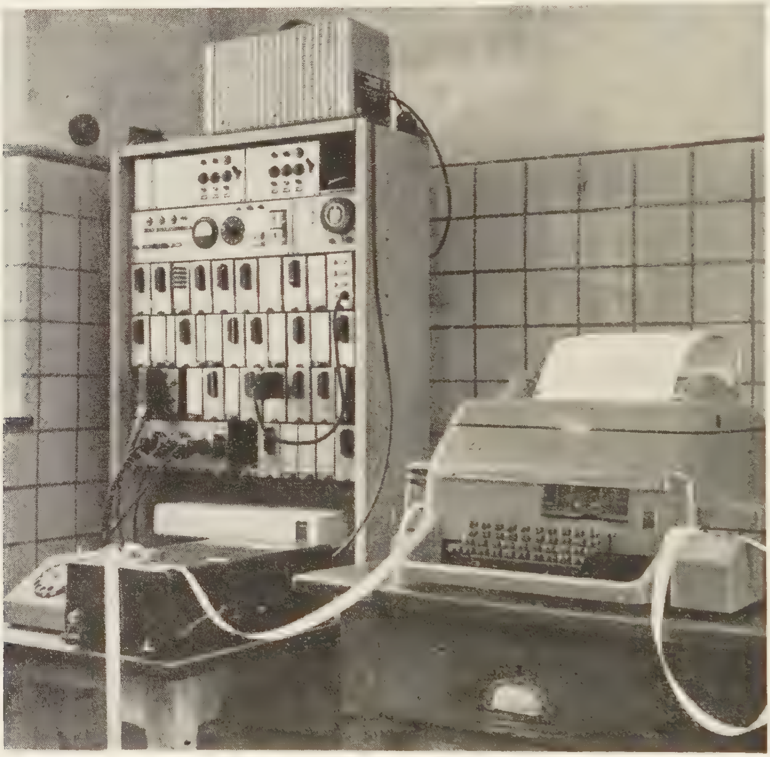


Fig. 15. — Teleprinter X with device for checking the transmission.

7. **Conclusions.**

The new method which has been used at Montzen for the last 18 months, has been of interest from three points of view.

7.1. *The quality of the work.*

A comparison of figures 3 and 7 immediately shows to what extent the new method reduces the personal intervention of the staff which is likely to produce or transmit errors; with this method in fact, such intervention is limited to an elementary reading off of the facts on the wagon by the clerk on the site, to the listening to these facts by his colleague in the office and to the simultaneous making out of the train statement.

On the contrary with the old method, errors could creep in :

— whilst the train statement was being compiled out on site, often under very difficult conditions;

— in translating the train statement to the exchange document;

— during the manual perforation of the mechanographical entry cards;

— during mark sensing on these same cards for the outgoing data.

It is therefore not surprising that the introduction of the new method had done away with the greater part of the disputes caused by errors in the exchange papers.

7.2. *Savings in labour.*

At Montzen, the suppression of the translation of the train statement into an exchange document has made it possible to reduce the staff by three, in the other stations, the saving will be in the same proportions.

At the Mechanographical Centre and in the B.C.R. the automatic making out of the cards and the elimination of a greater part of the investigations required on account of disputes has made it possible to reduce the staff by some 12 employees, for the whole of the exchange stations.

7.3. *Working conditions for the staff.*

Working conditions for the staff are definitely better, in particular :

a) the clerk on the site no longer has to prepare the train statement under what are often very difficult conditions (rain, snow, poor light, etc.);

b) the work of translating the train statement into the exchange document has been done away with;

c) manuscript documents which are often hard to read have been done away with;

d) the very fastidious work involved in ascertaining the outgoing data in order to complete the mechanographical entry cards has been done away with.

In conclusion, the S.N.C.B. is extremely satisfied with the trials of the new method of preparing the exchange documents; they intend to extend it as quickly as possible to the other important exchange stations.

[656 .237 (44)]

Evolution of the Commercial Organisation of the stations of the French National Railways,

by M. Cousin,

Ingénieur en Chef, Chef de la Comptabilité et du Contrôle des Recettes de la S.N.C.F.,

and M. Bernon,

Ingénieur principal, Chef Adjoint de la Comptabilité et du Contrôle des Recettes de la S.N.C.F.

(From the *Revue Générale des Chemins de fer*, December 1960.)

We consider it of interest to publish, with the permission of the authors, a condensed version of the study which appeared under the above title in the December 1960 issue of the « Revue Générale des Chemins de fer ». The Foreword, introducing the study in question, is reproduced in full below.

FOREWORD.

The rapid and spectacular evolution of the railway in technical matters is apparent to the least knowledgeable observers. Its evolution in commercial matters is no less real, but is less noticeable; often the business of specialists, it does not attract the attention of the public in the same way as electric station, modern signalling or train speeds.

In this modernisation of its commercial equipment, the French railways have endeavoured to keep up with progress in this field as well.

This modernisation is being carried out in several fields, the chief of which will be recalled below :

— the tariffing, the considerable evolution of which since the war has been the subject of various articles in this review : this evolution is not yet complete, and the very important reform known as ponderation of the distances, will shortly, it is hoped, see its preparatory labours terminated :

— scientific prospecting of the markets and the psycho-commercial training of the staff, in order to develop their salesmanship and relations with clients. The two fields are still in the course of evolution:

— finally the organisation of the stations and sales points in order to increase output and efficiency, and give clients a better service : this is an extremely important field as regards the harmonious working of a commercial entreprise such as the S.N.C.F. — the largest in the country — but in its main branches (receipts accountancy, taxation, transport statistics), its character is somewhat « hermetic » as we shall mention in due course.

It is however this field that Messrs. Cousin and Bernon are going to deal with, and we hope that even the non-initiated will find their report interesting.

Before we hand over to them, I would like to warn the reader of an error that the unwary might fall into : mention will be made of « centralisation » of the accountancy, « centralisation » of the taxation. At a time when decentralisation is very much to the fore, we do not want it to be thought we are going against the tide. The centralisation in question here is indeed a matter of fact, when things are looked at from the point of view of the small and average sized stations which are deprived to the profit of certain centres. But looked at on the national plane, it is in no way centralisation but rather a « regrouping » of activities : it will be seen that the accountancy centres number some 200, distributed all over the country.

In fact, it is rather a case of decentralisation actually since certain work now concentrated in Paris will in the future be spread over many provincial establishments, in particular as far as verification of the charges is concerned.

The regrouping of the work which we see therefore, on the commercial side, being required of the railway, is due in fact to the same policy as that which operates on the technical plane — modern signalling installations with a wide radius of action, centralised traffic control, regrouping of the marshalling yards, regrouping of the large maintenance shops.. Like all these, it is made possible by the invention of new tools — in this case modern calculating or counting machines, perforated strips, etc... and by the progress made with teleprinters...

In one as in the other case, the specialist tends, in the case of certain jobs, to take the place of the all round man; this must be seen not only as a source of increased efficiency but also as a more rational use of the resources of the human mind.

L. DELACARTE,
Traffic Manager of the S.N.C.F.

* * *

1. CENTRALISATIONS OF ACCOUNTS.

Until recently, the commercial operations involved in any transport were carried out at even the smallest stations, and in the important stations, the commercial, accountancy and cashier's work were spread over various localities. This dispersion, the fruit of an epoch when accountancy mechanisation was in its infancy, was not conducive either to efficiency nor security, as the same employees often were responsible for the accounts and the pay-office.

Concentrating the work thanks to modern office equipment and machinery, means increasing the productivity and the quality, in particular by the specialisation of the staff; it also simplifies the work of clients.

It is in reality the setting up of « centres » which leads to a complete study of the rational organisation of the commercial and accountancy services, whilst centralising at the same time the work of the adjoining stations.

1) Organisation of the commercial offices in the station selected as accountancy centre.

An analysis of the various commercial and accountancy operations of the stations allows of their classification into three main categories :

— Tariff and commercial operations.

Accountancy operations.

— Operations in connection with contentious business, should any occur.

It was thus logical to set up three sections :

— the traffic section;

— the accountancy section;

— the claims section.

Quite apart from the *Passenger Traffic* section, sited in the Passenger building, the *Goods Traffic* section includes, in addition to specialised groups (customs, for example) at least two groups :

— the Office group, responsible for all relations with clients : they supply information, accept traffic, send the papers to the rates fixing department and prepare the regulations;

— the rates fixing group, which receives the statements, classifies by category and numbers the documents before passing them to Accounts.

The *Accounts Section* consists of 3 groups :

— the mechanographical group, responsible for making out the accounts and imputing the charges under the different headings;

— the « R Accounts » group, which centralises the accounts of the stations belonging to the centre;

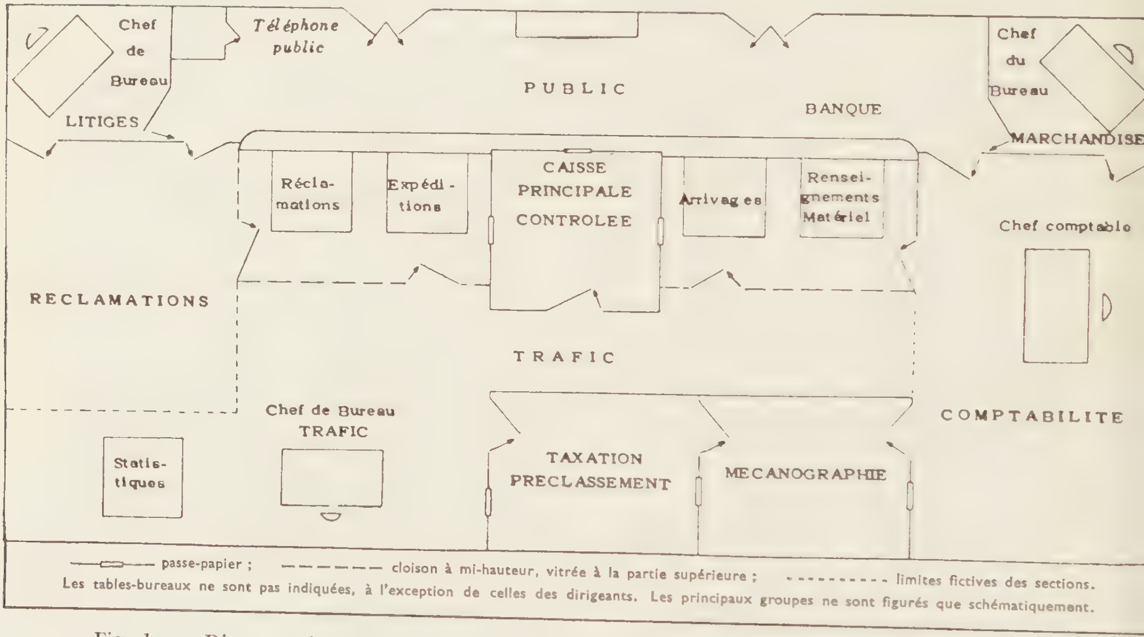
— the « Centralisation » group responsible for drawing up the daily operations and preparing the monthly statement of account for the Receipts Control Office at Paris.

The Section *Claims,* which consists of the employees responsible for dealing with litigation, goods that cannot be delivered and verifications, may, at large centres, be divided up into specialised groups.

Figure 1 shows a diagrammatic plan of a typical office organised on these lines.

2) The Accounts Section.

This, a real « accounts centre » includes all the accountancy staff of the station and is responsible for keeping the accounts, Passenger and Luggage as well as Goods.



——▭—— passe-papier ; — — — — — — — cloison à mi-hauteur, vitrée à la partie supérieure ; - - - - - - - - - - limites fictives des sections.
Les tables-bureaux ne sont pas indiquées, à l'exception de celles des dirigeants. Les principaux groupes ne sont figurés que schématiquement.

Fig. 1. — Diagram showing typical plan of a goods office, showing the separation between the different functional sections.

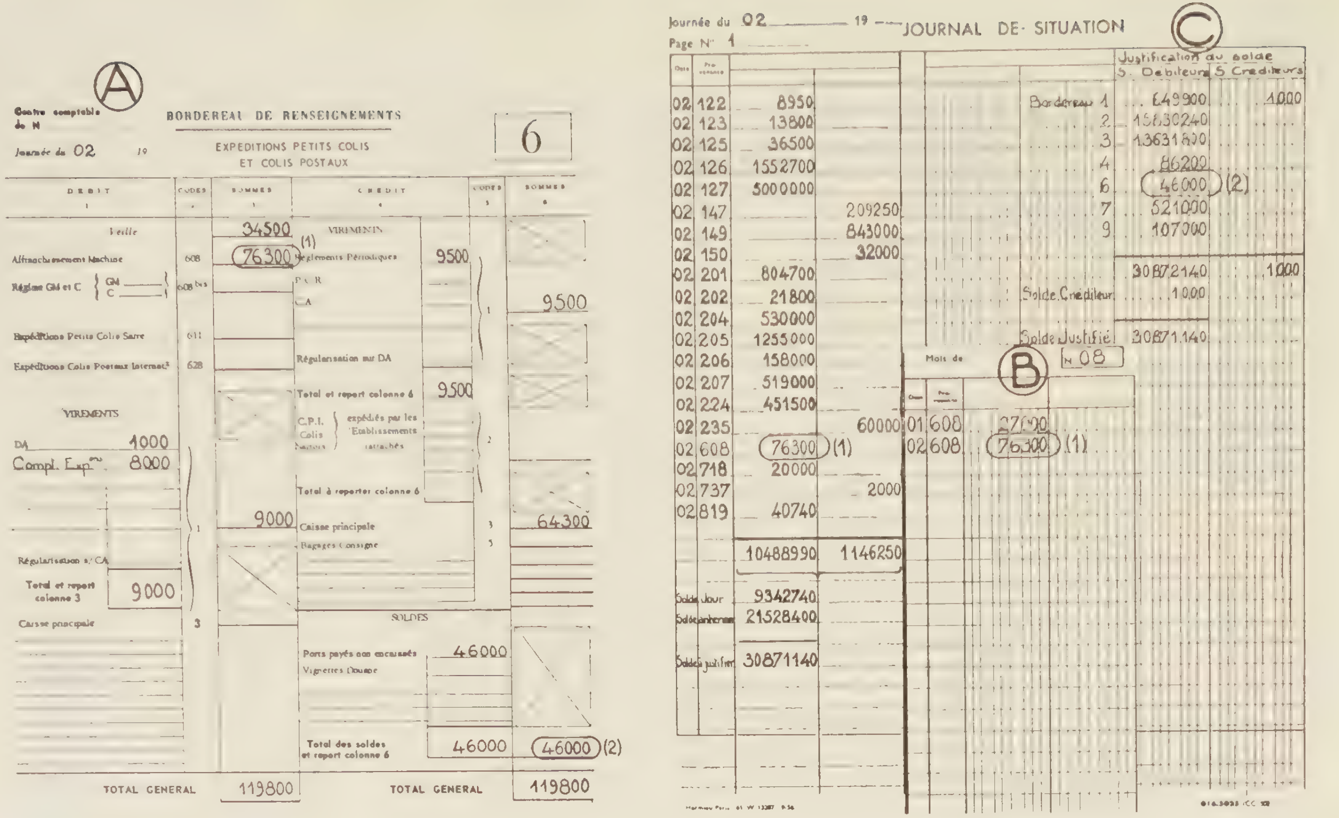
Explanation of French wording :

Chef de bureau, litiges = chief clerk, litigation. — Chef de bureau, marchandises = chief clerk, goods. — Chef comptable = chief accountant. — Telephone public = public telephone. — Banque = bank. — Réclamations = claims. — Expéditions = consigning. — Caisse principale contrôlée = main cash office under control. — Arrivages = arrivals. — Renseignements materiel = information on rolling stock. — Trafic = traffic. — Statistiques = statistics. — Taxation preclassement = preliminary fixing of prices. — Mécanographie = mechanography.

-▭- Openings for papers.
- - - Partition halfway, with glazed upper portion.
. . . . Fictious boundaries of the different sections.
The desks are not shown apart from those of the chief clerks.
The main groups are only shown diagrammatically.

These Sections are completed by a « Control Office », which checks all the cash in hand and payments solely from the statements prepared by the booking clerks who made out the bills. The complete separation of the accountancy and treasury operations is the best possible safety precaution.

It is run by the « chief accountant » which is the top grade in this job; he is fully and permanently responsible for the whole of the work and must possess in addition to his qualities as an accountant, those of an organizer and instructor; in particular he is the technical adviser of the sta-



Centre comptable de N

Journée du 02 19

BORDEREAU DE RENSEIGNEMENTS

EXPEDITIONS PETITS COLIS
ET COLIS POSTAUX

6

DEBIT 1	CODES 2	SOMMES 3	CREDIT 4		CODES 5	SOMMES 6
Veille		34500	VIREMENTS			
Affranchissement Machine	608	76300 (1)	Règlements Périodiques	9500	1	
Réglem GM et C { GM / C }	608 bis		P.C.R.			
			CA			9500
Expéditions Petits Colis Sarre	611					
Expéditions Colis Postaux Internat.x	628		Régularisation sur DA			
			Total et report colonne 6	9500		
VIREMENTS			C.P.I. Colis Postaux { expédiés par les Établissements rattachés }		2	
DA 1000						
Compl. Expons. 8000			Total à reporter colonne 6			
	1	9000	Caisse principale		3	64300
Régularisation s/CA			Bagages Consigne		5	
Total et report colonne 3 9000						
Caisse principale	3		SOLDES			
			Ports payés non encaissés	46000		
			Vignettes Douane			
			Total des soldes et report colonne 6	46000		46000 (2)
TOTAL GENERAL		119800	TOTAL GENERAL			119800

Journée du 02 19 — JOURNAL DE SITUATION

Page N° 1

Date	Provenance		
02	122	8950	
02	123	13800	
02	125	36500	
02	126	1552700	
02	127	5000000	
02	147		209250
02	149		843000
02	150		32000
02	201	804700	
02	202	21800	
02	204	530000	
02	205	1255000	
02	206	158000	
02	207	519000	
02	224	451500	
02	235		60000
02	608	76300 (1)	
02	718	20000	
02	737		2000
02	819	40740	
		10488990	1146250
Solde Jour		9342740	
Solde antérieur		21528400	
Soldes justifiés		30871140	

	Justification du solde S. Débiteurs	S. Créditeurs
Bordereau 1	649900	1000
2	15830240	
3	13631800	
4	86200	
6	46000 (2)	
7	521000	
9	107000	
	30872140	1000
Solde Créditeur	1000	
Solde Justifié	30871140	

Mois de

N 08

Date	Provenance	
01	608	27000
02	608	76300 (1)

Fig. 2. — Accounting for daily operations by card and daybook.

A. Statement drawn up by each clerk or accounts employee to record all the operations of the day.

B. Card CC 502 F prepared for each account that is finalized (¹).

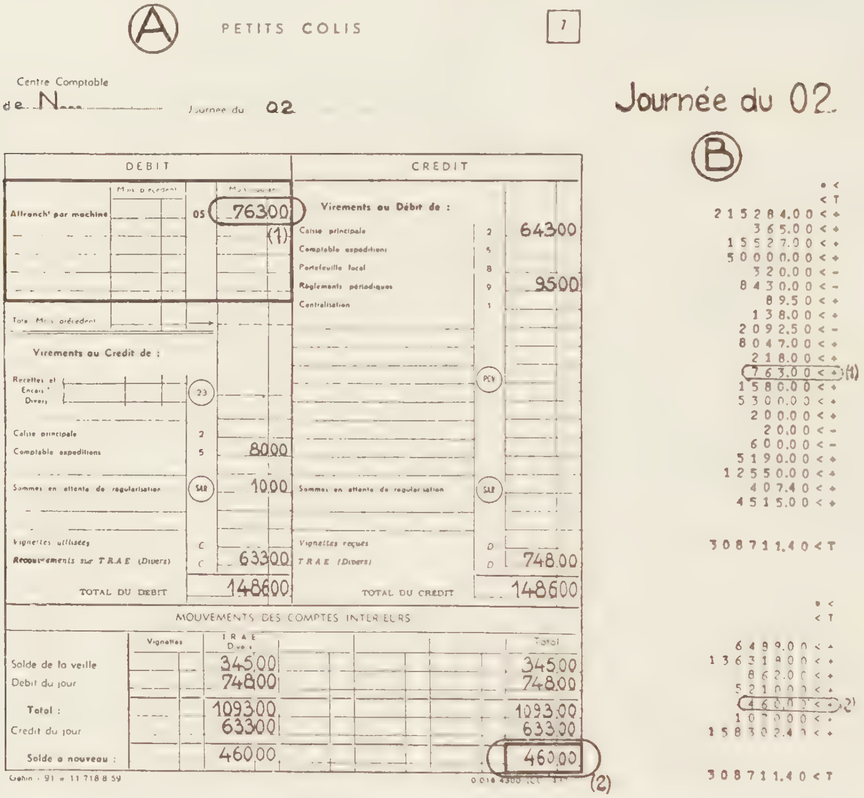
C. Journal CC 502 J on which there is a carbon copy of each entry on the different cards (balance to be checked) and a direct entry of the other items of the account (balance checked) (²).

The balancing of the accounts is verified by the balancing of the two general balances.

tions attached to the centre concerning the simple accountancy operations they still have to carry out.

Special mention must be made of 2 steps forward recently made :

nature; in the other the same items are classified according to the way they are met. At the end of the day, these are checked by checking the identity of the algebraical sum of the balances of the two accounts.



PETITS COLIS 7

Centre Comptoble
de N
Journée du 02

DEBIT				CREDIT		
	Mois précédent		Mois courant			
Affranch' par machine		05	763.00	Virements ou Débit de :		
				Caisse principale	2	643.00
				Comptable expéditions	5	
				Portefeuille local	8	
				Règlements périodiques	9	95.00
				Centralisation	1	
Total Mois précédent		→				
Virements au Credit de :					PCV	
Recettes et Encais' Divers		23				
Caisse principale		2				
Comptable expéditions		5	80.00			
Sommes en attente de regularisation		SAR	10.00	Sommes en attente de regularisation	SAR	
Vignettes utilisées		C		Vignettes reçues	D	
Recouvrements sur T.R.A.E. (Divers)		C	633.00	T.R.A.E. (Divers)	D	748.00
TOTAL DU DEBIT			1486.00	TOTAL DU CREDIT		1486.00

MOUVEMENTS DES COMPTES INTERIEURS

	Vignettes	T.R.A.E. Divers				Total
Solde de la veille		345.00				345.00
Debit du jour		748.00				748.00
Total :		1093.00				1093.00
Credit du jour		633.00				633.00
Solde a nouveau :		460.00				460.00

Gehin - 91 - 11 718 8 59

Journée du 02

```
         • <
         < T
215284.00 < +
   365.00 < +
 15527.00 < +
 50000.00 < +
   320.00 < -
  8430.00 < -
    89.50 < +
   138.00 < +
  2092.50 < -
  8047.00 < +
   218.00 < +
   763.00 < +
  1580.00 < +
  5300.00 < +
   200.00 < +
    20.00 < -
   600.00 < -
  5190.00 < +
 12550.00 < +
   407.40 < +
  4515.00 < +

308711.40 < T
```

```
         • <
         < T
  6499.00 < +
136319.00 < +
   862.00 < +
  5210.00 < +
   460.00 < +
  1070.00 < +
158302.40 < +

308711.40 < T
```

Fig. 3. — Accounting for daily operations by strip.

A. The standard statements are preprinted : the better presentation and readability makes them suitable for dealing with directly. Note the frames in thick type which bring out the items in the finalized balance (¹) and the totals of the internal accounts (²) to be included.

B. The addition of the finalized items then the internal accounts makes it possible to check the balancing of the accounts.

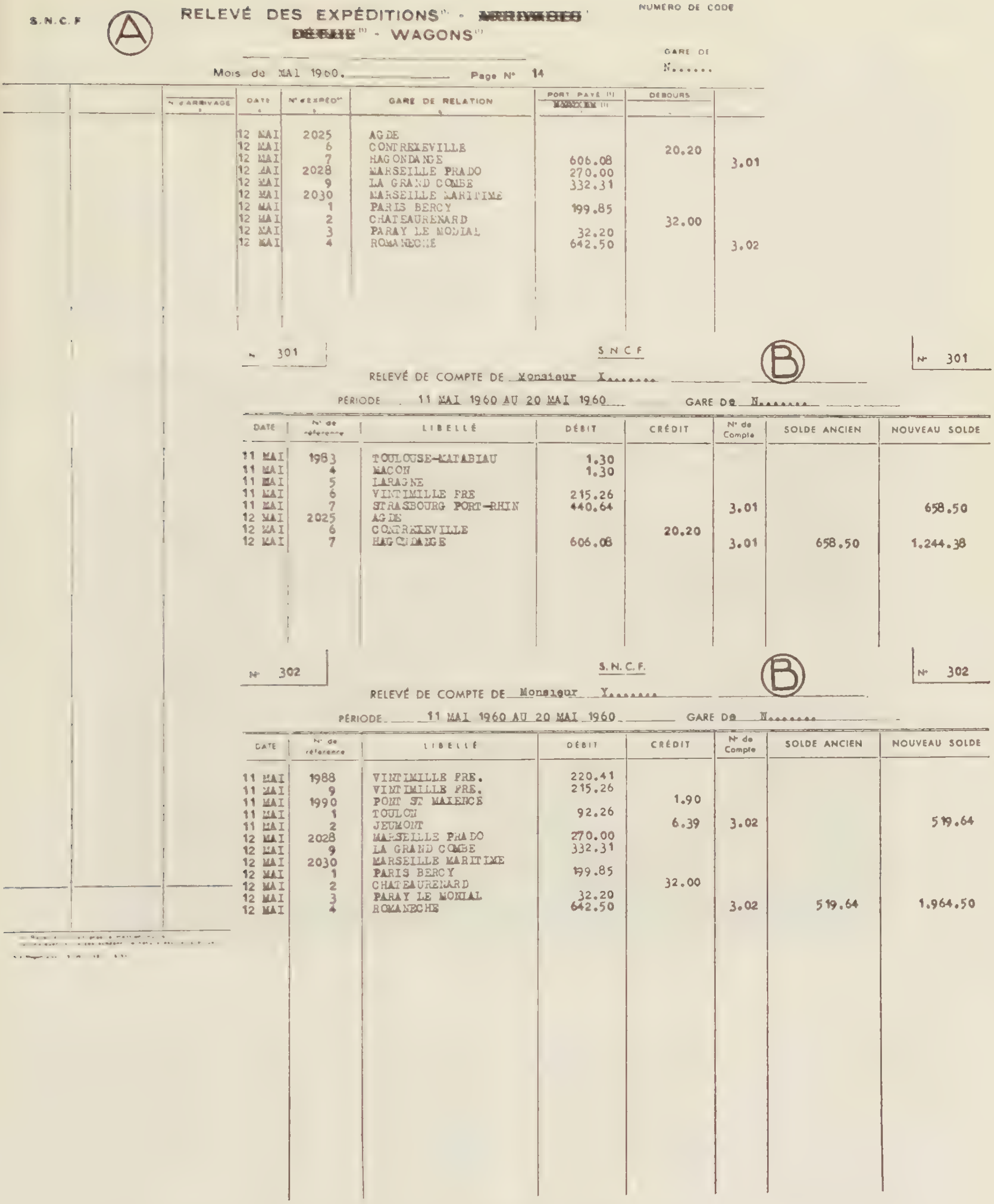
The adding up strip takes the place of the journal CC 502 J completely.

The CC 502 F cards themselves have been done away with, as there is already a monthly statement of the daily statements made for each account to be finalized.

a) *Drawing up the daily statements.*

As everyone knows the centre keeps two different accounts : in the first are recorded the receipts and expenditure of the stations on behalf of the S.N.C.F. according to their

A system of cards already explained in an article by M. SCHERER, which appeared in the December 1956 issue of the *Revue Générale des Chemins de fer,* represented considerable progress over the old method



S.N.C.F (A) RELEVÉ DES EXPÉDITIONS(1) - ~~[illegible]~~(1) ~~DÉTAIL~~(1) - WAGONS(1)

NUMERO DE CODE

GARE DE N.......

Mois de MAI 1960. Page N° 14

N° d'arrivage	DATE	N° d'expédon	GARE DE RELATION	PORT PAYÉ (1) ~~[illegible]~~ (1)	DÉBOURS	
	12 MAI	2025	AGDE			
	12 MAI	6	CONTREXEVILLE		20.20	
	12 MAI	7	HAGONDANGE	606.08		3.01
	12 MAI	2028	MARSEILLE PRADO	270.00		
	12 MAI	9	LA GRAND COMBE	332.31		
	12 MAI	2030	MARSEILLE MARITIME			
	12 MAI	1	PARIS BERCY	199.85		
	12 MAI	2	CHATEAURENARD		32.00	
	12 MAI	3	PARAY LE MONIAL	32.20		
	12 MAI	4	ROMANECHE	642.50		3.02

N° 301 S N C F (B) N° 301

RELEVÉ DE COMPTE DE Monsieur X.......

PÉRIODE 11 MAI 1960 AU 20 MAI 1960 GARE DE N.......

DATE	N° de référence	LIBELLÉ	DÉBIT	CRÉDIT	N° de Compte	SOLDE ANCIEN	NOUVEAU SOLDE
11 MAI	1983	TOULOUSE-MATABIAU	1.30				
11 MAI	4	MACON	1.30				
11 MAI	5	LARAGNE					
11 MAI	6	VINTIMILLE FRE	215.26				
11 MAI	7	STRASBOURG PORT-RHIN	440.64		3.01		658.50
12 MAI	2025	AGDE					
12 MAI	6	CONTREXEVILLE		20.20			
12 MAI	7	HAGONDANGE	606.08		3.01	658.50	1.244.38

N° 302 S.N.C.F. (B) N° 302

RELEVÉ DE COMPTE DE Monsieur Y.......

PÉRIODE 11 MAI 1960 AU 20 MAI 1960 GARE DE N.......

DATE	N° de référence	LIBELLÉ	DÉBIT	CRÉDIT	N° de Compte	SOLDE ANCIEN	NOUVEAU SOLDE
11 MAI	1988	VINTIMILLE FRE.	220.41				
11 MAI	9	VINTIMILLE FRE.	215.26				
11 MAI	1990	PONT ST MAXENCE		1.90			
11 MAI	1	TOULON	92.26				
11 MAI	2	JEUMONT		6.39	3.02		519.64
12 MAI	2028	MARSEILLE PRADO	270.00				
12 MAI	9	LA GRAND COMBE	332.31				
12 MAI	2030	MARSEILLE MARITIME					
12 MAI	1	PARIS BERCY	199.85				
12 MAI	2	CHATEAURENARD		32.00			
12 MAI	3	PARAY LE MONIAL	32.20				
12 MAI	4	ROMANECHE	642.50		3.02	519.64	1.964.50

Fig. 4. — Example of financial statement got out.

The statement for consignments (A) and the accounts of the different clients who pay periodically (B) are got out mechanographically by duplication.

The position of each client's balance can be ascertained instantly from the balance for the former operations (old balance).

(keeping a register of the daily business, in which was entered the information taken from all the different day-books). Starting with the *particular* accounts of each station, this made use of the office statements (see fig. 2-A) adapted to requirements, and including :

— settled items (first series of accounts);

— transfers between offices;

— credits from internal accounts (second series of accounts).

The accounts were prepared by writing on a card and in a journal (fig. 2-B and C) the sums in question, and directly in the journal the credits from internal accounts. The equality of the algebraical sums of each order was an assurance that the daily accounts were balanced.

The rational organisation of the centres according to precise rules, which are the same for all of them, has made it possible to introducce a *typical accountancy plan,* sufficiently flexible to be adapted to the needs of each centre, from which the standardised office statements were created (see fig. 3-A).

To check the daily balance, it is sufficient, in fact, to add the sums taken directly from these statements corresponding on the one hand to the sums shown on the debit side and credit side of the settlements, and on the other hand to the amount of the balances of the internal statements.

Fig. 5. — Accounts section : office of the « mechanography » group.

A simple adding machine strip takes the place of cards and journal (fig. 3-B).

By comparing figures 2 and 3, even a person without specialised knowledge can appreciate the great simplification this makes.

b) *Mechanography.*

Experience has fully confirmed the hopes raised as soon as they appeared on the market of the advantages to be obtained from using simple 2 or 3 counter machines equipped with automatic functions.

Thanks to the so called frontal insertion device, these machines can prepare simultaneously the financial statements intended for the Receipts Checking Department and the statements for clients who pay their transport fees periodically (fig. 4 and 5).

These latter statements are always kept balanced, i.e. after each inscription or series of inscriptions, the new balance is inserted; in this way, clients can see the position of their accounts at any moment and at the end of the period have full details of the operations carried out.

3) Harmonisation of the zones of the accountancy centres with the territory of agencies or traffic zones (C.T.).

The statistics supplied to the Head of the Agency are got out with the aid of the information prepared by the accountancy centre. It is therefore the standard practice for the accountancy section to prepare these documents.

This means that the boundaries of the Agency and the Accountancy Centre must coincide, and this has been done as far as possible. In this way, the accountancy centres form the first rung of the accountancy ladder, the second being the Receipts Accountancy Department and the third the General Accountancy Department.

II. RATES FIXING CENTRES.

Formerly the employees at small stations had the most varied duties to carry out : Accounts, Traffic, Train Services. Even when relieved of the main accountancy work, there was still a fear of their not being able to carry out the specialist jobs such as correctly rating the goods as well as their colleagues in the offices at the large stations. In fact, the mediocre quality of the rates fixing for « Wagons », was one of the preoccupations of the S.N.C.F.

After a study lasting several years, covering very varied experiences, centralisation which had given such good results in the case of the accountancy work was also introduced in the case of the rates fixing.

1) Rates fixing in 1950.

Il all the stations, the charges were settled when the consignment was notified. On arrival, the destination station checked these charges. Then the Goods Traffic Receipts Checking Department (C.R.M.), which received all these consignment statements in its turn checked these very thoroughly, and 10 % of them were also counterchecked, the stations being notified of any under or overcharging.

The necessarily long delays (1 or 2 months) after which clients were billed had the serious drawback of increasing their disatisfaction and favouring the activities of cut-price agencies.

2) Experiences of centralisation.

Sample tests confirmed that charges got out by specialist offices at the large stations were much more accurate than those of the small and medium sized stations. A few rates fixing centres were created and the value of their verifications on arrival were regularly measured. These centres were called « Supervised centres ».

Amongst them, those whose percentage of error was less than 0.6 % were given the title of « Agreed centre », and the statements they sent in to the « C.R.M. » were no longer required to have a complete check, only a sample 10 % being counterchecked.

In this way, the overall monthly percentage of errors found by the « C.R.M. » declined at a regular rate from 2.25 in 1956 to 1.4 at the end of 1959, being divided up as follows :

0.3 % for the Agreed Centres;
1 % for the Supervised Centres;
3 % approx. for the other stations.

These results, which only refer to the quality of verification on arrival, the only thing that could conveniently be measured, are very encouraging all the same. They confirm the value of rate fixing Centres, equipped with modern facilities adapted for their special work, and run by specialist staff (fig. 6).

5) Generalisation of rates fixing Centres.

Taking into account the information obtained from the above experiences, the S.N.C.F. decided, in February 1960, to generalise Rates fixing Centres. It expected to obtain from this the two following essential advantages :

— satisfied clients who would no longer be asked to pay the difference when undercharged and would no longer be suspicious of the accuracy of the charges they were asked to pay;

— a very considerable saving in the work of checking the accounts, as now only 10 % of the statements would have to be checked, instead of checking them all twice, and then 10 % of them once more.

STAGES OF THE CENTRALISATION OF THE CHARGES

It must be pointed out that it is easier — because the booking clerk has more time — to check the charges correctly on arrival. Moreover, it is easier to gauge the quality of the verifications on arrival.

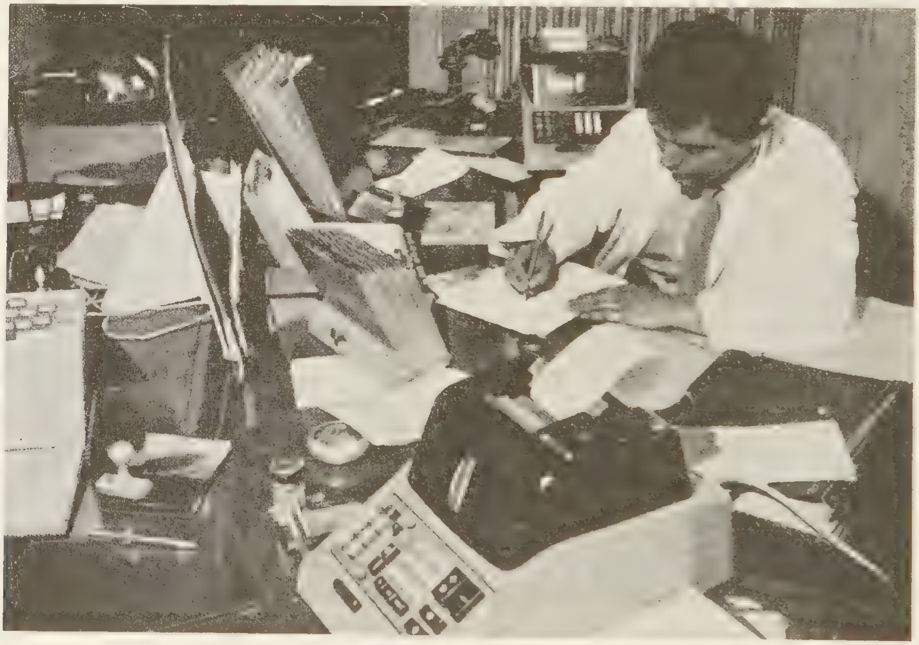


Fig. 6. — Traffic section « goods »; rates fixing clerk's office.

Consequently, the first stage was to generalise the Rates fixing Centres, which would coincide with the accountancy centres and would cover the whole of the S.N.C.F.

These centres, organised from the beginning as « Supervised Centres » had to be accepted for arrivals within a year, i.e. the number of mistakes in charging had to fall below 0.6 % by then.

In this way, the consignees of goods sent carriage forward would only receive a very small number of amended bills. On its side the « C.R.M. » would be able to make important savings in checking the charges.

During the second stage, the work of verification on arrival would be reduced, but the attention of the checkers had to be directed more particularly to the accuracy of the charges on departure.

In the final count, the S.N.C.F. would obtain the following advantages :

— disappearance of systematic verification on arrival, with correlatively a saving in employees' time;

— almost complete disappearance of corrected bills for carriage paid consignments.

4) The financial results of the operation and problems in connection therewith.

The reorganisation raises the problem of forwarding the transport documents. It is less of a problem on arrival where the documents (details of consigments and lists) must pass through the Accountancy Centre. But the centralisation of rates fixing *must not* in any case whatsoever delay the forwarding of the documents; the organisation of the work at the Centre must take fully into account the timetables of the trains serving the stations concerned.

Moreover, another problem was discovered which makes the centralisation of the charges still more necessary : it was caused by the creation, now in hand, of Inter-district Mechanographical Centres (C.M.I.A.) in which the consignment statements of the wagon traffic are dealt with mechanically as a constant flow and the statistics prepared. It is essential that there should be no errors in these documents, which means the verification and rectification of the codes denoting the essential data for getting out the statistics. A maximum percentage of errors — 3 % — was laid down, above which the passing of the Centre cannot be obtained.

III. CONCLUSION.

Accountancy Centres and Rates fixing Centres, having the same spheres of action and coinciding with the headquarters of the Agency or Traffic Area, are two aspects of one and the same evolution.

A rational economy and better quality of work with, in addition, a raising of the intellectual level of the work for which the men are responsible, are some of the undoubted advantages. On the other hand, the proper working of such centralisation means that there must be adequate telephone facilities and rapid transport of documents.

The S.N.C.F. in this way has fully entered into the modernisation of its buildings in the sense required by the most up to date techniques in connection with office work.

[62 (01 : 69]

The examination of massive masonry structures,

by Dipl.-Eng. Julius STRECKER, Munich.

(*Der Eisenbahn-Ingenieur*, No. 1, January, 1961.)

To assess the safety and the repairs requirements of massive structures showing visible damage on the surface, it is necessary to carry out an examination of the *internal structure.* As it was found that such examinations, if carried out with simple aids using sounding rods and rock drills, do not yield reliable results, tests were carried out with non-destructive physical methods, e.g. those-based on measuring the sound propagation time. But the application of such methods gives rise to difficulties due to the differences in the shapes of masonry and the irregularities of their structure. In contrast, it is possible to obtain reliable results, independent of the type and shape of the masonry, with the aid of *core drillings.* With this method, a hollow drill is driven into the masonry to the desired depth, and all the materials cut out by the drill, i.e. the drill cuttings, are taken out. From the condition of the drill cuttings and the borehole walls, it is possible to appraise the condition of the internal structure by visual inspection, whilst quantitative data can be obtained with the aid of normal methods used for the testing of building materials.

For the examination of geological conditions, core drillings are carried out with diameters up to 50 cm and more, and are taken to very great depths. For the examination of masonry structures, however, small drills and drilling depths of a few metres are sufficient.

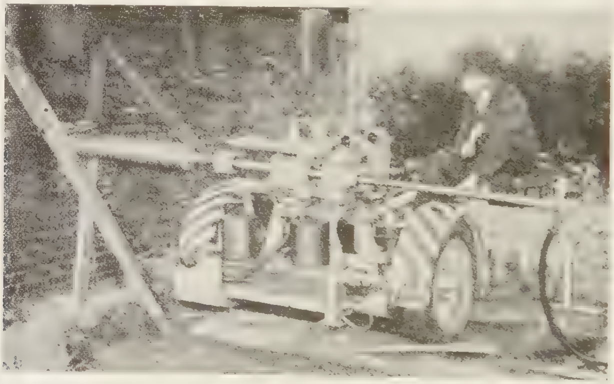


Fig. 1. — Drilling with a carriage mounted drill.

Core drilling machine (Fig. 1).

The machine, which consists of a boring tool with hydraulic feed, gearing, oil pump and driving motor, is mounted on a single-axle carriage which can directly serve as a drilling platform, and can easily be moved on roads and cross-country. If removed from the carriage, the machine requires but a small working platform (fig. 2). The different components are assembled as a unit mounted on a *movable* frame. The boring tool can be slued by 360° so that drilling can be carried out in any desired direction. The feed is 400 mm. The spindle speed depends on the diameter; with a bore of 150 mm, for instance, the speed amounts to 125 r.p.m. The quantity of water depends on the hardness and grain composition of the stone material and may amount to as much as 50 litres per minute. The water is pumped by means of a pump set mounted on a portable carriage, and is introduced into the drill through the hollow drilling rods.

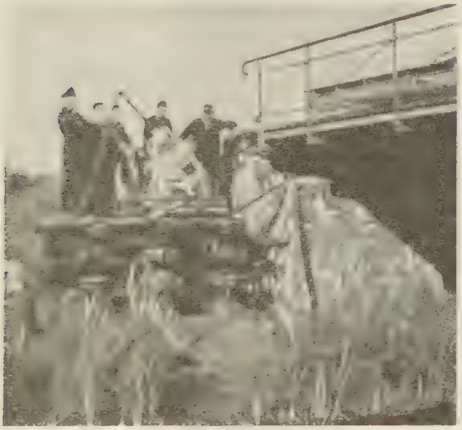


Fig. 2. — Downwards inclined drilling from a working platform.

The different types of core drills are distinguished by the shape of the borehole tube and the design of the bits. The simplest type consists of a steel tube with drill bit, and a tapered transition piece connecting the tube with the drill tube. The bits of this simple type have narrow lips permitting a high drilling rate. But these drills can only be used for horizontal or ascending boreholes where the drill cuttings do not slide out of the tube when the drill is retracted. With vertical or inclined downward drillings, it is necessary to use drills fitted with a core gripping device which consists of a slotted ring of conical cross-section located behind the bit in a corresponding recess on the inside of the drill. When the drill is retracted, this ring retains a firm grip on the drill core. But this device calls for bits with stronger lips, with the result that the drilling rate is reduced to about half the rate of a simple core tube, and the wear at the bit increases in keeping with the larger cutting surface. The length of the simple core tube, and the wear at the bit increases in keeping with the larger cutting surface. The length of the simple core tubes is adapted to the feed of the drill. By means of extension tubes, it is possible to carry out deeper drillings before the cuttings must be removed. For fragile cuttings, double core tubes with or without core gripping device may be used. With this type of equipment, the drill tube contains a second tube, mounted on roller bearings, which receives the cuttings so that these are not exposed to the effects of the drilling motion, and of the pressure-injected water which here flows through the space between the two tubes. Because of its heavier weight, however, this type of equipment can only be used for small diameter drillings.

The drill bits are fitted with carbide tips, carbide inserts, or diamonds which may be arranged in different ways (fig. 3). Carbide tipped bits which have the effect of grinding the stone material are used for drilling

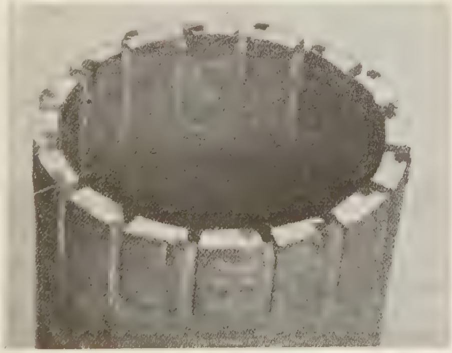


Fig. 3. — Carbide tipped drill bit.

homogeneous material; they require a high contact pressure and, hence, heavy machines. They are therefore of little or no use for the examination of building structures with irregular and, generally, unknown internal structure. Diamond tipped bits, on the other hand, can be used for any type of stone or masonry. They require but little contact pressure and have the special advantage, which is of particular value for the examination of the cuttings, that the cuttings obtained with their aid are of correct size and have smooth surfaces. The diamonds are embedded in a sintered metal alloy which has a high resistance against the stresses imposed by the drilling mud. Arrangement, size and number of the diamonds are, in each case, chosen on the strength of experience. The drillings are not accompanied by vibrations so that there is little risk of sensitive masonry being loosened.

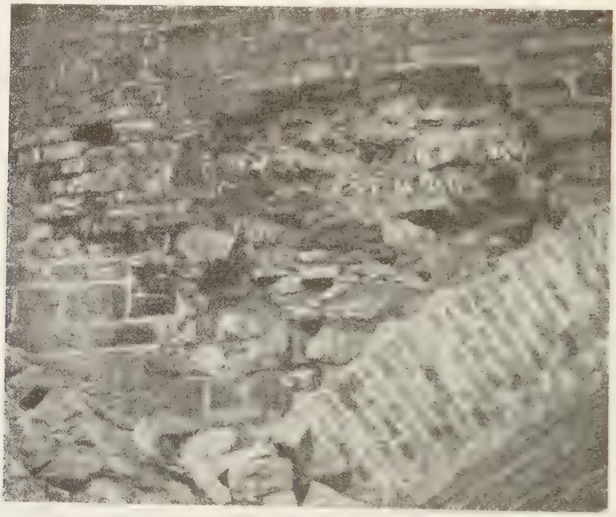


Fig. 4. — Drilling points in the head wall of a bridge arch.

The choice of the drill diameter is governed by the requirement to obtain, at low cost, drill cuttings which permit reliable conclusions regarding the condition of the masonry. The more solid and compact the internal structure of the masonry, the smaller is the drill diameter required. Stone material can be examined with the aid of small drills; for masonry, larger drills are required. A core diameter of 150 mm, corresponding to a borehole of 163 mm. diam. in the case of drills without core gripping ring, and to a borehole of 176 mm diam. in the case of drills with core gripping ring has been found suitable. With such drillings, the weakening of the masonry is insignifiant. Thus, a complete transverse drilling through a 4 m wide pier, will weaken the pier to the extent of about 4 % only, which does not give rise to any misgivings. If samples are to be taken from more delicate structural parts, it is advisable to use drills with smaller diameter. When the examinations are completed, the boreholes are sealed again by means of a concrete filling. It is also possible to use this opportunity for strengthening fractured masonry by the insertion of reinforcement steel.

Drilling method.

The choice of the drilling point is governed by the condition and position of the structure and by rail and road traffic considerations. In general, the drillings will be carried out at those points where the most telling results can be expected, e.g. in the vicinity of cracks or loose rock or at points where the stone has broken out or abnormal moisture is encountered, or in the case of tamped concrete, in the construction joints or at points of moderate compaction (fig. 4). If such drillings cannot be carried out from the carriage platform, it is necessary to erect a special working platform which may, for instance, consist of simple stacks of sleepers (cf. fig. 2). If drillings must be carried out at high levels, it will be necessary to use supported scaffolding or, where water is in the way, suspended scaffolding. The scaffoldings are rated for a concentrated vertical load of 1 500 kg from the weight of machine and operator, and for a horizontal contact pressure of 500 kg. In the case of masonry running closely parallel to the tracks, e.g. retaining walls or tunnel walls, the drill may be mounted on a railway wagon. Downward vertical drillings into a structure with ballast cover call for the provision of special protection tubes to keep out the ballast.

The number and depth of the drillings must be increased as much as is necessary for ascertaining the condition of the internal structure to be examined. With minor structures, two drillings are normally sufficient; with larger structures the number must be correspondingly increased. In certain circumstances, e.g. where a number of identical structures show similar damage, it may be advisable to investigate this damage by a more thorough examination with several and deeper drillings on one of the structures. The results will then permit conclusions in respect of the other structures so that the examination of the latter may remain confined to a few comparative drillings. A case in point is provided by the abutments of the bridge structure shown in figure 2, where the longitudinal faces are in contact with water; here, a thorough examination was carried out in order to gain insight into similar cases of damage experienced with identical structures (fig. 5). The drilling marked III was taken down to the bottom of the structure.

A comparatively great number of drillings are required for the examination of retaining walls consisting of rubble walling, or for the verification of the successful consolidation of masonry through mortar grouting. In a specific case where it was desired to verify the success of the trial grouting of a retaining wall of 300 m length, it was, for instance, necessary to carry out 18 drillings though most of them could be confined to a moderate depth.

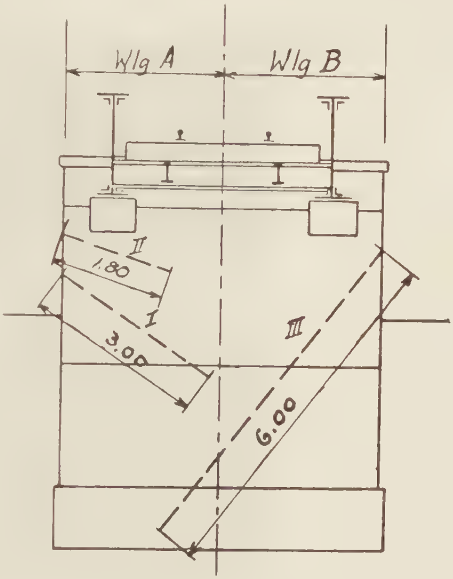


Fig. 5. — Position and depth of drillings carried out on the two abutments of the bridge shown in figure 2.

N. B. — Wlg (Widerlager) = abutment.

Evaluating the drilling results

The condition of the internal structure can be determined from the observations during the drilling, from the scrutiny of the cuttings, and from the assessment of the borehole walls. Even during the drilling, it is possible to draw certain conclusions concerning the condition of the structure from the rate of progress of the operation. The hardness of the masonry or stone is reflected in the resistance to penetration, encountered by the drill. With a constant contact pressure, the resistance is in direct relationship with the penetration rate. With diamond drills not provided with gripping ring and with a drill diameter of 150 mm, the rate of progress in hard natural rock, is less than 1 cm per minute; with B 300 concrete, it is about 2 cm and with softer varieties of rock correspondingly higher; in clinker and brick walls, the rate ranges from 5 to 8 cm per minute. A loose stone structure is liable to cause the drill to become wedged, which may impede the rate of progress considerably. The colour of the injection water flowing back from the hole is indicative of the type of masonry encountered and, in conjunction with changes in the progress rate, indicates a transition from one type of wall to another of different quality. Any loss of injection water inside the wall, and any emergence of the water at certain points on the surface, is indicative of the porosity and permeability of the wall and, with concrete walls, of the condition of the construction joints. If the structure is compact, the water returns from the borehole; if the structure is fissurized, the water will wholly or partly spread through the masonry and will often emerge at quite remote points. The observation of such phenomena indicates the possibility of consolidating the masonry through mortar grouting.

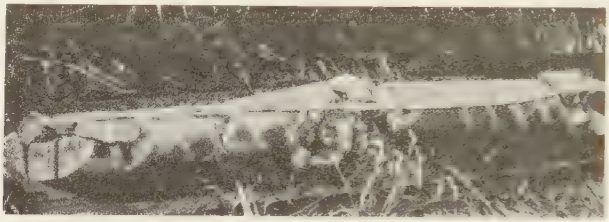


Fig. 6. — Drill cuttings taken from a brick wall.

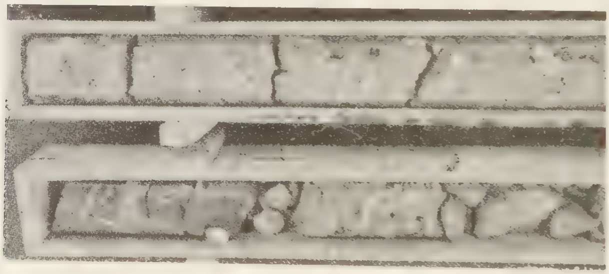


Fig. 7. — Drill cuttings taken from a concrete abutment.

The most important criterion for assessing the quality of the internal structure is provided by the drill cuttings. These provide a direct picture of the materials of which the structure consists, and of their condition. If the different lengths of the drill cuttings are laid out end to end in the order in which they had been extracted from the structure, one obtains a coherent picture of the structure at the cross-section explored by the drilling (fig. 6 to 8).

Drill cuttings taken from high-quality

masonry consist of long and solid core lengths. Coursed walling will only yield solid cores if the mortar itself has a high strength and good adhesion. If, due to washing out or poor construction workmanship, these properties are not present, the drill cuttings will crumble during drilling. If, on that occasion, the mortar is dissolved and washed out, the cuttings eventually obtained will consist of the stone material only, as is apparent in a part of figure 8. The core from a brick wall illustrated in figure 6 has been obtained from the inclined drilling shown in figure 2. The good bond between mortar and brickwork shows that, in spite of the wet surroundings, the old masonry structure had not suffered any major damage. The drill cuttings obtained from the concrete disclose the granulometric composition and void percentage as well as rock pockets and construction joints; they also convey an approximate idea of the water/cement ratio. The granulometric composition of the concrete shown in figure 7 is not good; there is a shortage of medium-sized aggregate and of cement, though the concrete is well compacted. These visual observations can be corroborated by means of hammer blows, and by scraping the mortar with a steel pin.

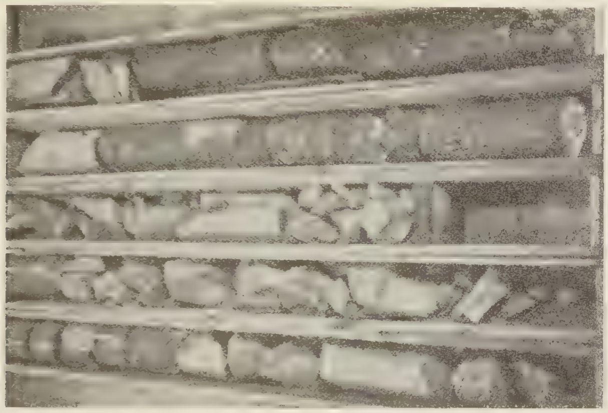


Fig. 8. — Drill cuttings taken from masonry consisting of natural stone with slag concrete back fill.

Quantitative data concerning the properties of the drill cuttings are obtained by means of laboratory tests. Depending on the requirements, these tests include the determination of the compressive strength of the drill core and, with coursed walling, also that of the stone and mortar separately; specific gravity; cleavage strength; frost resistance; voir percentage, and modulus of elasticity. Figure 9 shows drill cores prepared for strength testing. Before the cylinder surfaces are made good with mortar, it is necessary to remove coarser irregularities to obviate the risk of the results being falsified through unilateral or separation stresses. In working out the cube crushing strength, the influence of shape must be taken into account. The cube strength may be assumed to amount to 1.15 times the strength obtained with the 30 cm high cylinder. When crush testing the cylinder specimens, it must be remembered that the direction of the forces applied during the test is not the same as that in the structure, as it will rarely be possible to carry out the drillings in the corresponding direction. In the case of well compacted concrete, this does not give rise to ambiguities. But even with low-quality tamped concrete, the results are liable to be considerably affected by the position of the construction joints and the direction of tamping. In the case of coursed walling the strength of the walling is governed by the strength and shape of the brick or stone material and by the alignment and thickness of the joints. With regular coursed walling with thin joints, there is, within certain limits, no appreciable difference between the strength of the stone or brick and that of the wall as a whole, provided that the courses are laid with good workmanship. In this case, the crushing strength of the stone material is therefore tested in the position which it occupies in the wall. In the case of cylindrical drill cores with oblique joints (fig. 6), it is possible to draw, from the crushing strength in the axial direction, conclusions concerning the adhesion between mortar and brick or stone. With rubble walling, the mortar percentage increases with the irregularity of the stone material; the mortar is liable to be irregularly distributed in large lumps which may impair the strength. The properties of drill cuttings which, because of shape irregularities or because of an unfavourable alignment of the joints, are not suitable for crush testing by normal methods, may in certain cases be determined from the cleavage strength. This strength has a certain empirically known relationship with the tensile and compressive strength. With this method, the test specimens are exposed to loads which are applied at two opposite generatrices and which are increased until the specimen is broken. The fracture occurs through cleavage in the surfaces determined by the alignment of the compression stresses. Ashlars from regular coursed walling are tested by methods laid down in the Standards, whilst the testing of the mortar depends on the volume and shape of the drill cuttings available. With regular coursed walling, and in particular with brick masonry, the mortar forms thin layers which are not well suited for machine testing. Since the influence of the mortar on the strength of the wall as a whole is small, it is sufficient to judge the mortar, without using special aids, by scraping it with a steel pin and breaking it by hand, the criterion being whether it is impossible, difficult or easy to break a layer of a certain thickness by hand, or whether the mortar can be crushed and triturated between the fingers. Such an appraisal must be based on empirical comparisons. Thin layers of high strength mortar are tested by determining the flexural tensile strength. If the drill cuttings contain large lumps of mortar of, say, first size, it is possible to carry out

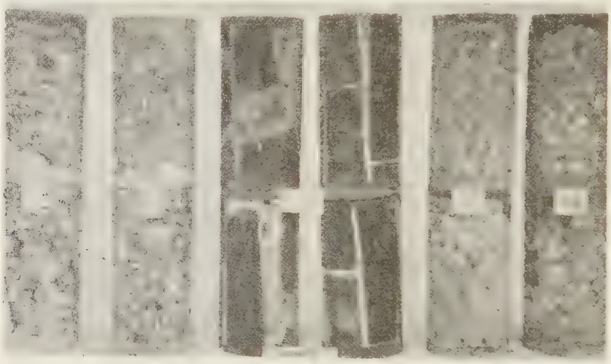


Fig. 9. — Drill cores prepared for crushing strength testing.

more extensive tests, e.g. with the aid of the ball impact hammer. With irregularly shaped specimens, it may be advisable for them to be embedded in mortar in order to obtain a perfect support. Instead of using the ball impact test, it is also possible to measure the penetration of a steel pin by means of a device similar to the needle penetrometer used for the testing of cement, and to assess the strength by means of comparative tests. The specific gravity and the air space ratio provide indications for assessing the mortar strength. The frost resistance test may be of importance even with old structures if the masonry is exposed to new influences, e.g. due to a rise in the water level. The success of a mortar grouting operation can be ascertained by comparing the crushing strength of the drill cuttings obtained before and after the grouting.

If solid drill cores are obtained, the tests carried out on them provide adequate criteria for judging the quality of the masonry. But if the drill cuttings are fragmentized, the tests carried out on them must be supplemented by an examination of the borehole walls. With a borehole of 163 mm diam., the developed area of the borehole surface amounts to 0.51 sq. m. per metre of drilling depth. If the walls are inspected with the aid of a torch, it is possible to ascertain whether the internal structure is compact, or whether it shows cavities, cracks or cleavages. By introducing a mirror held in a 45° position, the width and depth of the cavities can be ascertained. Figure 10 shows the compact structure of brick walling in a drill hole of 1.65 m depth. The bricks are properly and closely laid. The drill cores were obtained in solid lengths and their strength was found to be similar to that of backing bricks of Mz 100 quality. In figure 11, the cleavage between clinker facing and sand concrete backing is clearly visible. The cleavage is located in the concrete bonding which suggests that the concrete has a lower strength than the clinkers. This was corroborated by tests which showed the crushing strength of the concrete to be 147 kg per sq. cm., whilst that of the clinkers was 250 kg per sq. cm. The pit at the bottom of the concrete represents a construction joint. In the case of the borehole shown in figure 12, the cuttings merely consisted of stone fragments, and their tests provided no clue concerning the alignment of the crack or the condition of the walling. When the crack was examined under the torch, it was found to end in the facing

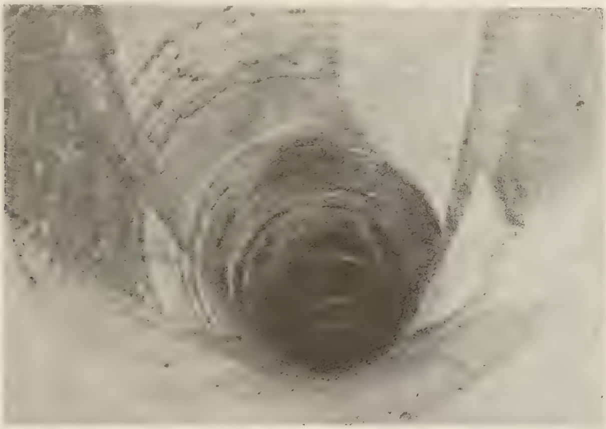


Fig. 10. — Borehole wall in brick masonry.

zone, and to stop short of the backing. With the large ashlars used in this case, the unfilled cavities did not signify any substantial weakening of the masonry. A similar condition is visible in figure 13. The annular open joints are not due to cleavage but to insufficient filling during construction. The mirror which, for the purpose of the photograph, had been inclined but slightly, shows the presence of a cavity. If the mirror is placed in the normal position, it permits the determination of the direction and depth of the cavity.

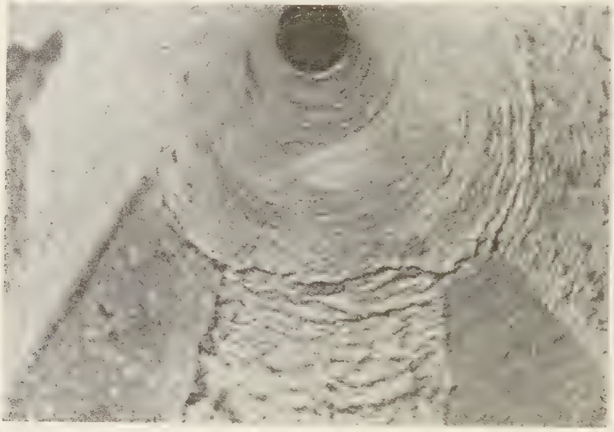


Fig. 11. — Borehole wall in tamped concrete with clinker facing.

Assessing the condition of the structure on the strength of the drilling results.

Damage encountered on structures may be due to faulty design, to the selection of unsuitable materials, to poor workmanship, or to inadmissible stresses. Long time exposure to moisture is nearly always a cause of damage, and often the only cause; it is particularly harmful with low-quality concrete and with rubble walling. In the following, it is intended to show by means of some examples how the causes and extent of damage can be ascertained by means of core drillings.

The brick abutments of a structure standing in water showed signs of deterioration, with exfoliations from the surface and with cracks emanating from the foundation slabs; the cracks were so extensive that they gave rise to misgivings about the stability of the structure, and the reconstruction of the abutments was contemplated. Core drillings showed, however, that the condition of the internal structure did not correspond to the picture obtained on the outside. Even the first drilling, taken to the centre of the abutment and below water level to a depth of 3 metres, yielded solid drill cores of remarkably good quality, already shortly after the drilling had commenced. This favourable result seemed to call for further test borings extending into the fissurized parts of the masonry structure below one of the bottom slabs and down to the bottom of the foundations at 6 m depth. These drillings showed that the structure consisted of homogeneous, well fired bricks with a mean crushing strength of 220 kg per sq. cm., and of a mortar with good inherent strength and adhesion. The strength of the drill cuttings did not decrease at greater depth. The foundation concrete, made from brick debris, had a specific gravity of 1.98 and a cube crushing strength of 163 kg per sq. cm. Further examination under the torch revealed that the mortar in the joints had been attacked by the injection water over a short length of the drill hole, but that the structure was otherwise compact. A crack which, at the surface, had a width of 5 mm went no further than into the first brick where it ended in a number of fine fissures. Apart from the loose stone material in the copings, no major weakening of the masonry structure was observable. The damage was not due to the foundations or to the influence of the river water or subsoil water, but to the rain and to uneven stresses imposed on the coping by concentrated loads. The findings led to the conclusion that expensive repairs were unnecessary, and that rehabilitation work could be confined to the replacement of the coping by a reinforced concrete sill and to the reconditioning of the visible surfaces of the wall.

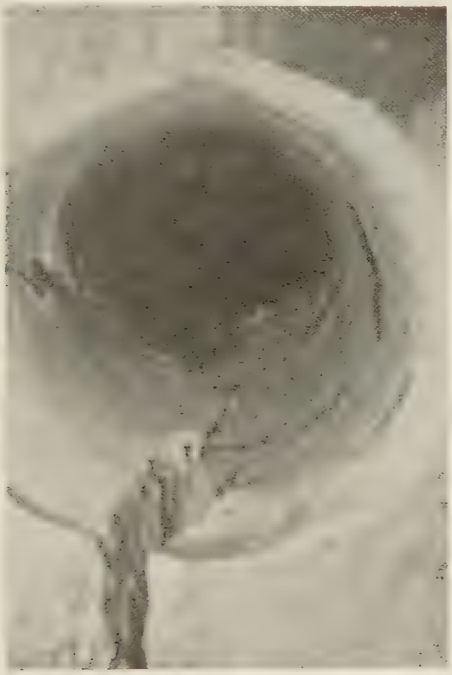


Fig. 12. — Borehole through a vertical crack in the pier.

Bulging of facing walls above vaults or similar structural parts may be encountered where the facing has become detached or where, due to sliding, pressure is exerted by the backing. If the mortar in the facing has deteriorated due to the effect of water, the facing may become detached because, due to their shape, the stones are generally inadequately bonded, being set fair at the surface but, depending on their shape, bonded with the backing by wide mortar joints. In this case, the core drillings will reveal an annular cavity around the borehole behind the facing whilst the backing yields solid cuttings. If no such cleavage can be discovered behind the bulged facing, the latter has generally been deformed by the pressure of an unstable backing. The loose condition of the structure is then apparent from the drill cuttings and from the cleft borehole walls. In such cases, the stone material of the walls can often easily be broken loose by means of a hook; in fact, the condition of the material can frequently be ascertained even earlier, during the drilling, inasmuch as the drill gets

Fig. 13. — Examining a borehole by means of a mirror.

wedged. Figure 4 shows a zone of approx. 2 sq. m., where the facing has broken out and the backing has thereby been laid bare. To examine the masonry, one core drilling operation was carried out through the zone of damage, and another at a distance of 1 m from its edge. The first drilling, taken to a depth of 2.5 m, did not yield any solid cores but only small stone fragments of irregular shape, with traces of mortar. An examination of the borehole wall revealed that the mortar had become decomposed into sand, up to a depth of 50 cm, and that it was possible to break the stones loose by hand. At greater depth, the masonry was more solid but cleavages were encountered throughout, and right down to the end of the drilling, no compact structure was formed. It did, however, become difficult and, finally, impossible to break the stone material loose by means of the hook. The zone of damage showed lime deposits.

The cuttings obtained from the second drilling, which was taken to a depth of 2.2 m, consisted of individual stones in a splintery condition, and of lumps of masonry with mortar of good adhesion. The fine-sand type mortar contained stones of a size up to 30 mm. Lumps of mortar of 1.5 cm thickness could only with difficulty be broken by hand; their compressive strength was about 35 kg per sq. cm. The examination of the borehole wall showed, also at this point, a cleavage behind the facing, followed by masonry rich in mortar, with slightly cleft structure and with lime deposits. The result of the examination was that, in the zone of the first drilling, both the facing and the backing had lost their stability through the mortar having been washed out, or decomposed, and that the damage had been worsened through pressure, possibly due to accumulated water. Due to deficient bonding between facing and backing, the cleavage between them had become extended over a surrounding zone although, as the second drilling showed, the backing had here remained stable. The marked degree to which the damaged zone had been washed out was due to an accumulation of water conditioned by the structure of the masonry. The damage had to be attributed to poor workmanship and inadequate insulation.

Figure 14 shows parts of a vault and pier of a bridge with several spans. The head voussoirs of natural stone are well bonded with the concrete of the vault but had become detached over a length up to the quarter points of the semi-circular vault. From the springers, cracks run along the surface of the pier, downwards and towards the centre, which indicate an uneven force distribution. When, in order to ascertain the cause of the damage, core drillings were carried out at several piers of the bridge, the core of the piers was found to consist of a concrete whose composition and strength varied greatly as between one drilling and another, and even within the same drill hole. This must be attributed to an inexpert choice of aggregates, such as shaly stone material, and to insufficient compaction. Seven different drill cuttings, taken from three drillings of 1.5 m depth each, showed the following crushing strength values :

Drilling No. I : $\sigma_w = 67$; 206; 273 kg per sq. cm.;

Drilling No. II : $\sigma_w = 42$ kg per sq. cm.; the remainder of the cuttings being unsuitable for crushing strength tests;

Drilling No. III : $\sigma_w = 135$; 45; 81 kg per sq. cm.

The mean of the seven values amounts to $\sigma_w = 122$ kg per sq. cm. These piers, which thus contain a concrete that, because of its heterogeneous composition, is of low quality, are faced with the same material as the head voussoirs, viz. a compact limestone which, on being tested, was found to have a specific gravity of 2.7 and a crushing strength exceeding 1 150 kg per sq. cm. The strength of this material is thus about ten times higher than that of the core concrete, and the elasticity values can be assumed to have about the same proportion. If the crushing strength of the vault concrete, which was not included in the investigation, is assumed to be $\sigma_w = 300$ kg per sq. cm., it follows that the structure has been constructed in three different materials of so widely different qualities and properties that their interaction was not possible without giving rise to damage.

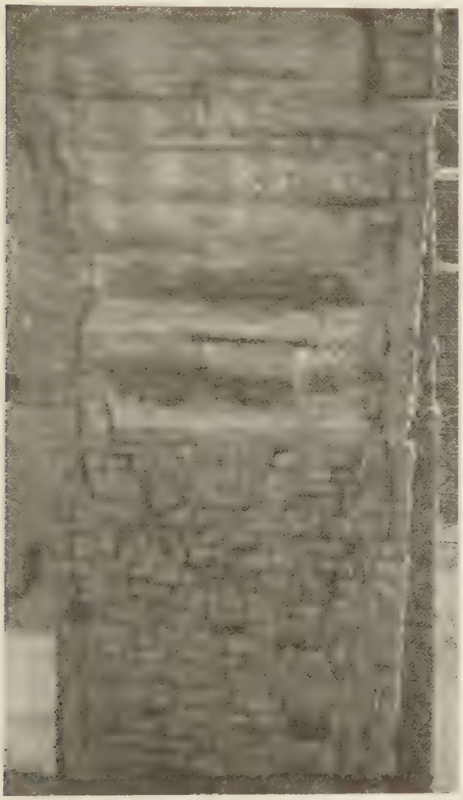


Fig. 14. — Cracks in the facing of a pier.

Consolidation of masonry by means of mortar grouting.

For the reconditioning of structures, the process of consolidating the masonry by means of mortar grouting has assumed great importance. This method is suited for all types of masonry whose internal structure contains cavities. But the method can only be used if the condition of the structure to be grouted is known, since it is this knowledge which must govern the composition of the mortar, the number and location of the injection points and indeed, the decision about applying the method at all. It is always advisable to verify the success of masonry grouting by means of core drillings. The mortar is liable to be uncontrollably dissipated in cleavages inside the masonry so that the intended in-filling of the masonry may not have been achieved even though the theoretically calculated quantity of mortar has been injected. Figure 15 shows a drill cutting taken from a concrete abutment which, prior to the grouting, had been found to consist mainly of irregularly shaped lumps of concrete unsuitable for testing. A core portion of about 20 cm length had then shown a crushing strength of 68 kg per sq. cm. Pure cement mortar, without additives, which had a water/cement ratio of 0.8, was injected in the concrete under a pressure of 12 kg. per sq. cm. As the photograph (fig. 15) shows, the cavities were filled and their fine ramifications reached by the mortar which had been pre-

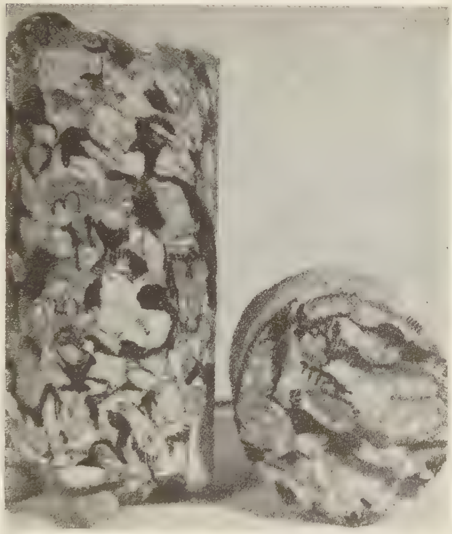


Fig. 15. — Concrete consolidated by mortar grouting.

pared in a high-speed mixer. The crushing strength was increased to 120 kg per sq. cm. despite the fact that the old mortar which, though compact, was of low quality, had not been consolidated itself. With this consolidation, the concrete abutment had again attained the necessary degree of safety.

Figures 16 and 17 show partial results of a verification test carried out on a mortar grouted retaining wall of some length, which consists of random and snecked rubble walling, and where the backing had been constructed with a certain lack of care. The wall is built up from irregular stone riprap, from gravel or sand, or from a mixture of sand and stones. The verification test revealed the difficulties offered by the wall to consolidation by mortar grouting. The drillings were carried out at the centres of the zones which were limited by several injection points. With the drilling shown in figure 16, the drill entered, immediately behind the facing, a cavity not reached by the mortar. In contrast, the borehole of 1 m depth shown in figure 17 reveals an internal structure completely sealed by the mortar injection. In this case, the cleft mass of stone had been completely consolidated by the mortar.

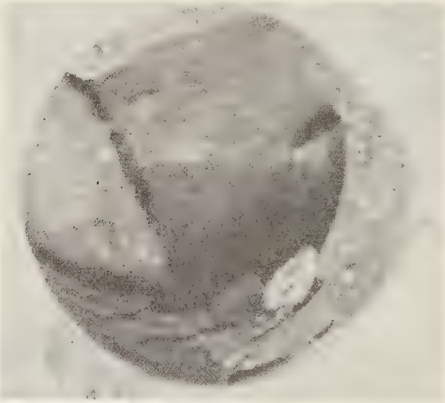


Fig. 16. — Unsuccessful grouting of masonry.

Core drillings are generally carried out in order to ascertain the condition of the internal structure, or to investigate certain specially notable properties of the material. It may, for instance, be desired to ascertain the compressive strength of a natural stone material forming part of a structural component whose cross-section is to be reduced, or to determine the modulus of elasticity of ashlars of a high and slender bridge pier. But, as the following example shows, core drillings may also be carried out for economic reasons or to avoid disturbance to traffic provided that they are expertly planned and reliably executed. In connection with the renewal of the insulation of a railway arch bridge spanning an urban street, with heavy traffic, it was also necessary to repair a drain which had become blocked. As this repair work was likely to be very expensive, it seemed preferable to provide a new drain, and to obtain it simply by means of a core drilling. For this purpose, it was necessary to obtain a borehole of 163 mm width, emanating from a given point on the intrados and emerging at a given point on the extrados of the vault. The horizontal and vertical distances of the two points required a drilling angle of 25° upwards inclination (fig. 18). The drilling, in concrete throughout, had a length of 7.85 m and its plane was to be perpendicular to

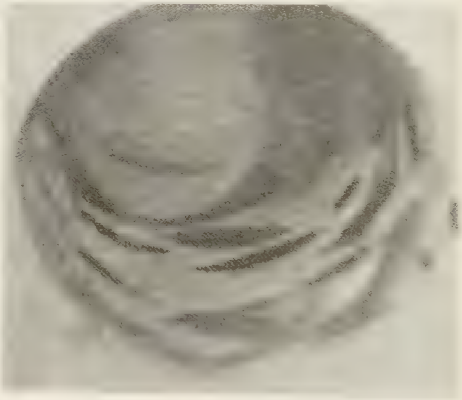


Fig. 17. — Successful grouting of masonry.

the wall surface. The target point on the extrados was reached after two days, without lateral deviation, but with a slight deviation of 6.8 cm upwards, due to the sag of the drill rodding. There was no deviation at a drilling depth of 5.45 m. At a depth of 6.45 m, the deviation was still no more than 1.5 cm, but it then increased by 5.3 cm over the remaining drilling length of 1.4 m. The sag, and hence the deviation, can be avoided if the rodding is held in position by support rings which are fitted with ball bearings and are inserted into the borehole.

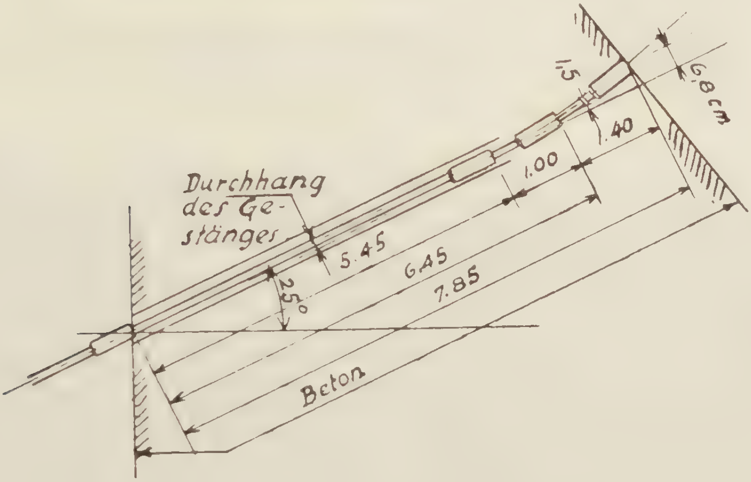


Fig. 18. — An example of target drilling.

N. B. — Beton = concrete. — Durchhang des Gestänges = sag of drill rodding.

[**621** .131 .3 (42) & **625** .172 (42)]

New dynamometer car for British Railways.

Electronic instrumentation and strain-gauge load cells incorporated in an unique design.

(*The Railway Gazette*, May 19, 1961.)

Following a lengthy analysis of present and future requirements for the track-testing of all types of locomotives and rolling-stock, a dynamometer car of unique design has been produced at the Swindon Works of British Railways, Western Region.

In the design and equipment of this car, provision has been made for the accurate testing and recording of test data over a wide field, of which the following are typical examples :

i) Controlled road testing in which all the usual traction and resistance characteristics are obtained with the train running at the varying speeds of normal route operation. The information thus obtained over all sections of the region is charted by the test department in a form convenient for direct use by the traffic staff in compiling passenger and freight train schedules;

ii) Investigation of mechanical and electrical problems arising under normal working conditions of Diesel and electric locomotives;

iii) Investigation of general problems such as adhesion, braking, stressing of components, and vehicle riding characteristics.

To undertake this very comprehensive range of testing, the car is equipped with the most modern potentiometric and electronic instrumentation, and in effect is a mobile laboratory.

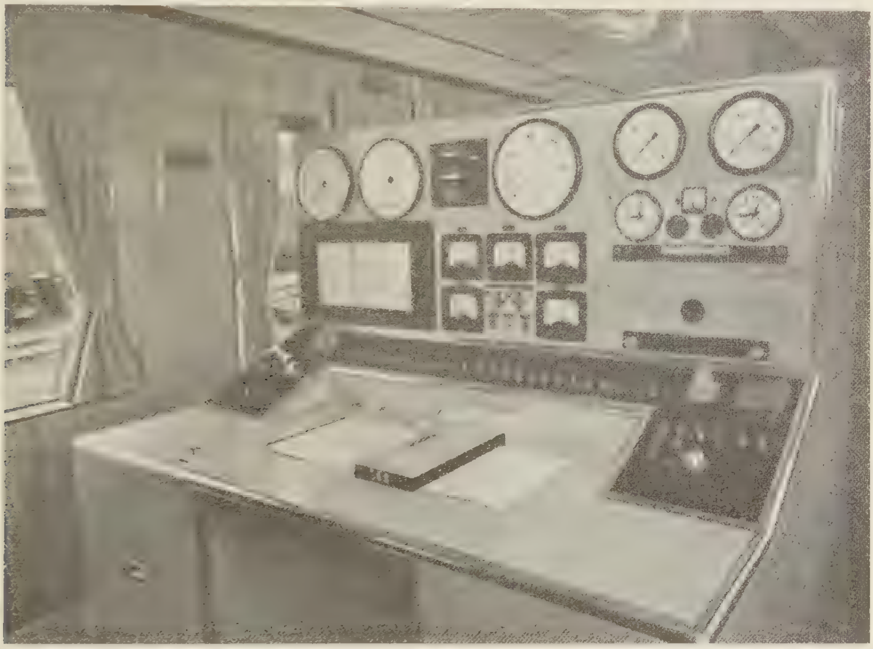
By the use of electrical load cells as used for industrial weighing, instead of the orthodox hydraulic dynamometer equipment, it has been possible to convert an existing vehicle with the minimum of modification to the underframe and running gear.

The vehicle used is a 63-ft. corridor second class coach built in 1947. The underframe is of the four-truss type and carried on 9-ft. light pressed-steel bogies. The 11-ft. drawbars are articulated at the bogie underframe bolsters, and the normal drawhooks and couplings have been replaced by the stronger Continental patterns. Testing can thus be carried out from each end of the car.

A Diesel-powered alternator set has been installed to provide a self-contained source of stabilised electrical supply for operation of the electronic, potentiometric, and other types of instruments, for lighting and water heating, and for the electrical requirements of the self-contained heating system.

In the spacious dynamometer room is a permanent console for housing the traction recording and indicating equipment and the control equipment for the alternator set. Equipment and instruments required for special investigations are not permanently installed but are drawn from an instrument pool as required. This avoids the carrying, and subjecting to vibration unnecessarily, of instruments not in frequent use. Service connection panels and movable benches are provided for the operation of this supplementary equipment.

Three interchangeable transducer measuring elements of drawbar effort are provided in the following ranges: 0-10 tons, 0-20 tons, and 0-30 tons. Externally, all elements are 1 ft. 6 in. × 4 in. dia., increasing to 5 in. for a length of 5 in. in the centre, the ends being screwed internally for the drawbar connections.



Traction control console and recording table.

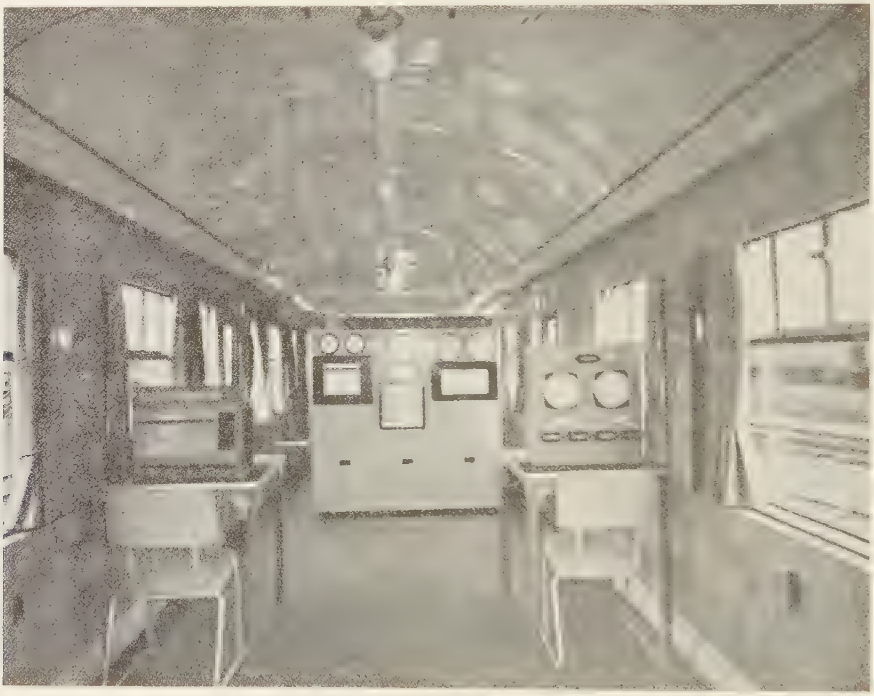
Essentially the transducers supplied by Elliott Bros. (London) Ltd. consist of ground load-carrying billets, on each of which are mounted two strain-gauges of matched characteristics which enable their functions to be switched if and when necessary. One normally serves the effort pens of both main traction and effort-speed recorders; the other the effort member of the work integrator.

The gauge units are sealed and waterproofed and are completely protected by strong steel sheaths. A dummy takes the place of the measuring element at the non-test end, and dummies are used at both ends when the car is not testing.

Insertion of the measuring elements and dummies in the drawbars is effected through floor traps in the vestibules. Rubber springs at the articulated end of the drawbars relieve the measuring elements of severe shocks. The free ends of the drawbars are suspended from spring pendulum links to avoid rubbing friction.

To prevent errors in effort measurement on curves, the buffers at each side are attached to the ends of a centrally pivoted swing link.

For measuring distance run, the tyre profiles of one set of wheels have an inclination of 1 in 100. To permit formation of these from the standard tyre section, the nominal diameter of all wheels has been fixed at 3 ft. 7 in., i.e. 1/2 in. less than the standard as new. A gearbox, mounted on what is normally the seat of the driving pulley of the train-lighting generator, transmits distance run to the well of the traction console by a shaft drive. Compensation for tyre wear of the measuring wheels can be conveniently effected within the car. Brakes are not fitted to these wheels.



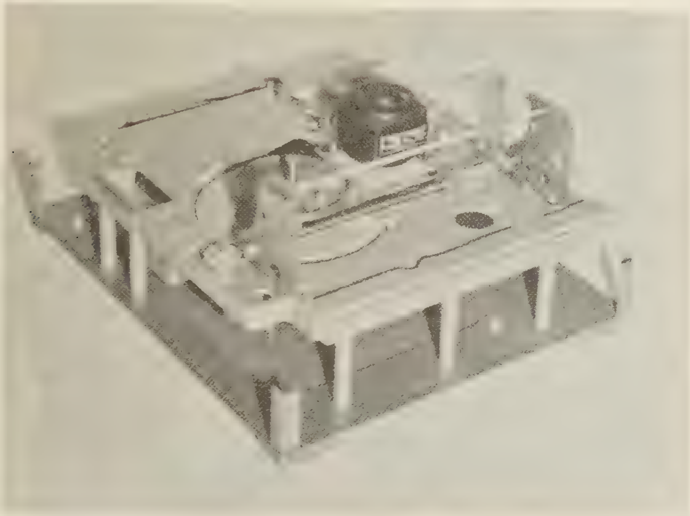
Mobile laboratory equipment in dynamometer car.

Traction console.

The traction console carries, in both forward- and backward-facing panels, large-dial indicating instruments of drawbar HP, drawbar effort, train speed, locomotive air-brake pressure, and train-pipe vacuum; also of gradient and other track features on charts which move automatically at 2 in. per mile run. The indications on the one side are clearly readable from all parts of the supplementary instrument section and of the dynamometer room and, on the other, from the central control panel and main recorder, and from a conference room beyond.

Allocation of instant marker pens.

The instant markers are allocated to location by quarter-mile posts, time (at 0.1 and 1.0 min intervals), work done (at increments of 1.0 and 10 d.b. HP/h), and distance increments at choice, the remaining pens being available for fuel or other consumptions and for co-ordination purposes.



Dynamaster potentiometric bridge unit.

The vertical panel on the central control side also carries the racks of the electronic time and counting units and counters of work done, mileage run, and distance run during braking and similar periods. The other panel carries the recorder of train speed either on a distance base or on a convenient time base. The same panel carries the XY recorder of drawbar effort and train speed.

On the flat main recorder table a length of 2 ft. 3 in. of paper band is exposed, the band passing from and to the concealed magazines below through narrow slits. The band is 1 ft. wide and the effort scale is 7 1/2 in. for the full-scale deflection of each of the three load ranges, leaving room for eight instant marker pens without overlap or offset.

The electronic time and counting unit is in three parts, each housed in a standard 19-in. rack, these being the stabilised power pack carried inside the console, the 100-kilocycle crystal oscillator and the counter, both of which are mounted in the vertical panel of the console adjacent to the main traction recorder. A supply at 50 cycles is produced for operating the synchronous motors of the standard-time and elapsed-time clocks, and of the pulsing mechanism which produces the pulses that are used in normal traction recording.

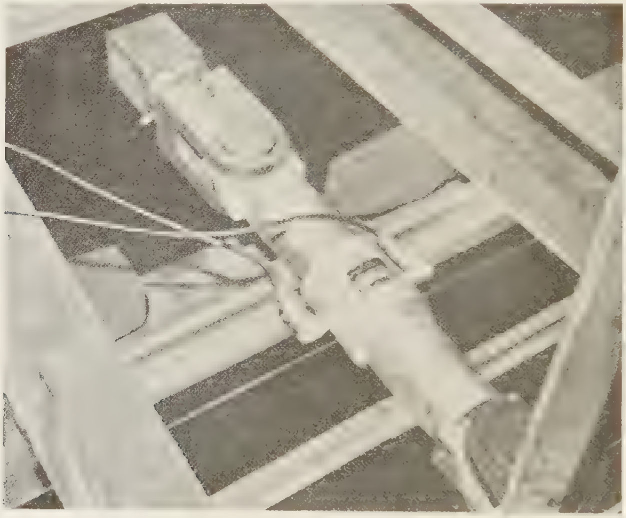
Distance is measured by the revolutions of one of the axles, transmitted by shaft drive to the well of the traction console, where the shaft is coupled to the input end of a Croft's positive forward-neutral-reverse clutch and gearbox. From this the drive is taken to a splitter box which provides five output shafts running at 440 rev. per mile.

The transducer measuring elements of drawbar effort and speed are used with potentiometric bridge units of the standard dynamaster pattern made by the Bristol Instrument Company, these being A.C. or D.C. instruments as required.

All units are capable of a maximum output torque of 15 oz-in. The unit measuring the drawbar effort is placed longitudinally in the centre of the console, simultaneously displacing the drawbar effort pen of the main recorder and the drawbar effort pen of the drawbar effort-train speed XY recorder.

Similar dynamaster units are used for charting other functions.

The centralised control over the electrical equipment is situated on sloping panels between the main recorder and the vertical panel of the console. The switches provided cover control of the alternator set, transducers, potentiometric bridge units, electronic time and counting unit, and various circuits of the main recorder.

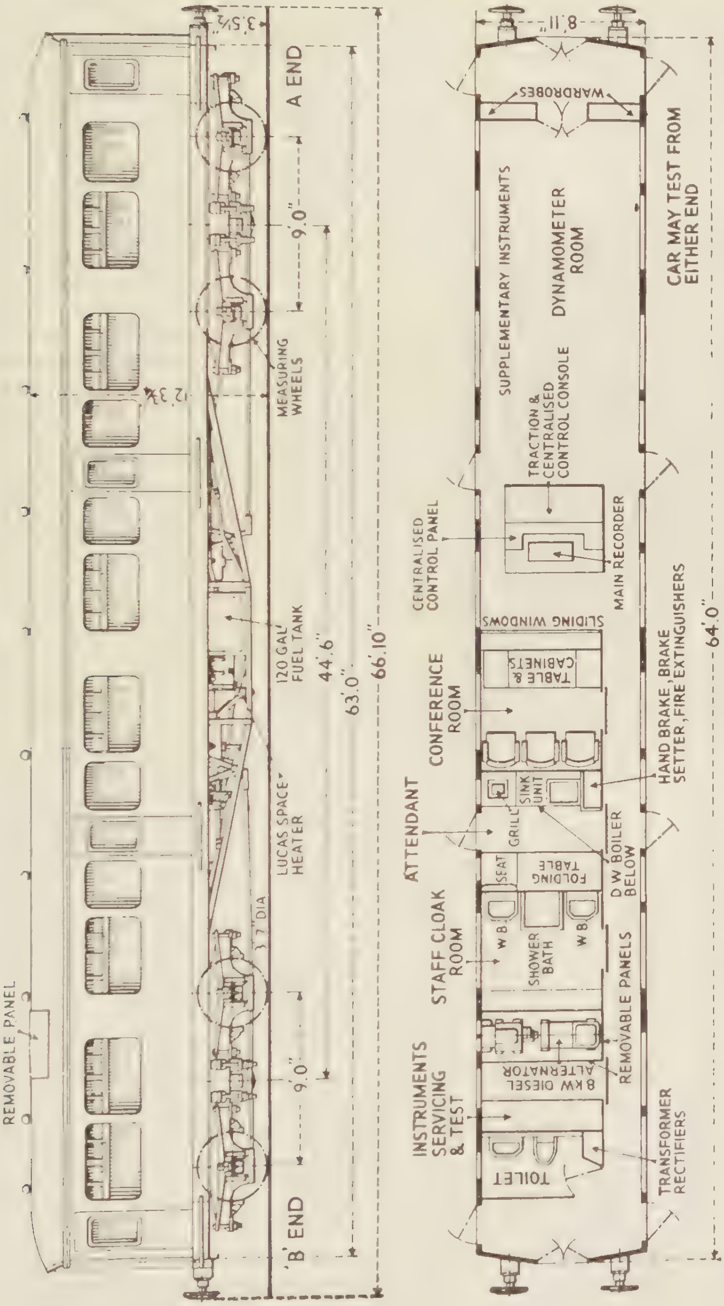


Drawbar transducer measuring element.

Conference room.

The first compartment toward the B end is a conference room 7 ft. 2 in. long in maximum dimensions. A sliding glass window in the dynamometer room partition, extending the full width, enables the near indicating instruments of the traction and central control console to be viewed from a sitting position. Below the sill of this window, with access from the dynamometer room, are the racks for the drawbar tension transducers and dummies, amplifiers, and recorder sundries. Beneath, and just above floor level, is the inlet to the re-circulating air duct of the heating system. In front of the dynamometer room window of the conference room is a table supported on two cabinets. An internal telephone system provides communication with all points.

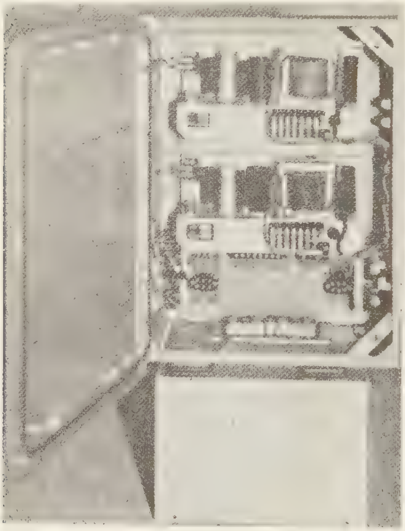
The next compartment in the B direction is the attendant's. It is fitted with a stainless-steel sink unit with hot and cold taps, drinking water supply through a caravan-type pump which lifts water from four 4-gal. stainless-steel containers, a 4-gal.



Side elevation and plan arrangement of dynamometer car.

drinking water boiler with two-heat immersion heater, and an electric hot-plate and grill. Against the other partition is a seat and a 4-ft. × 2-ft. table.

The third compartment is a staff cloak room with two washbasins and a shower bath cubicle, all with hot and cold supply.



Drawbar effort-measurement amplifier.

One-third of the fourth compartment from the dynamometer room is occupied by the 10-kW Diesel alternator operating on a power factor of 0.8. The Macfarlane 240-V 50-cycle single-phase transicon alternator, is driven by a Lister two-cylinder four-stroke water-cooled engine.

Air is drawn by the engine-driven fan through a floor vent, whence it passes round the set and is expelled through the radiator and thence through louvres in the side panels. The 24-V D.C. supply for low-tension D.C. instrumentation, emergency lighting, and engine starting is provided through a transformer-rectifier set which trickle-charges a 24-V 108-a.h. heavy-duty Exide battery. The whole cubicle is screened and insulated. The compartment and corridor panels are removable for servicing the set *in situ* while a removable roof panel enables it to be removed for workshop repairs. The remaining two-thirds of the compartment is fitted out as an instrument servicing and test room.

In the nearby cubicle are the transformer-rectifier sets for charging the main and portable instrument batteries for the three-phase 400-cycle supply and for the electrical supply to the oil-fired space heater.

The B end vestibule is fitted with instrument lead traps and connection panels similar to the A end.

Mains voltage cables are taken through below-floor steel conduits. Instrument leads are carried in 6 × 2-in. screened ducting. The run between the vestibule connection panels is placed on the corridor side, where it is immediately above the cant rail.

All ducting has hinged doors throughout, being flush with the roof panels when closed. The whole has been so arranged that leads may be laid out at floor level, harnessed, and lifted into position without threading.

Lighting is by four 240-V 80-W fluorescent light units in the dynamometer room and two 240-V 100-W filament lights in each compartment.

A Lucas combustion heater is installed for space heating. In this, combustion air and heating air are completely separate, each flow being induced by its own fan and filtered on entry. Temperature is sampled by the recirculation air, which can be varied between 70 % and 30 %, and the control thermostat is situated in the recirculation air duct.

A 125-gal. fuel tank suspended from the underframe supplies the Diesel-alternator and heater.

Water supplies are carried in roof tanks of 150 gal. total capacity. For the hot-water supplies, a 30-gal. tank directly fed from the main tanks is fitted with a 3-kW main immersion heater and a maintaining heater of 250-W.

Decor.

Floors, walls, and roofs are lined with laminated plastic and insulated for sound and heat. The dynamometer room has a ceiling in cream and walls of light « Walnut », with the exception of the A end wall, which is « silver grey walnut ». Floor covering, in marbled grey-green heavy-gauge linoleum, is renewable. The conference room is in « birds-eye maple » with a cream ceiling; floor covering is patterned in two shades of green, toning with the upholstery; furniture is in « walnut » softglow. Elsewhere, various light shades of plain and linette grey are used.

The design of the car was prepared to the requirements of Mr. R. A. Smeddle, Chief Mechanical & Electrical Engineer by his Research & Development (Rolling-Stock) Office at Swindon. The conversion was carried out in the Swindon Carriage & Wagon Works, which was also responsible for building the permanent instrumentation and the manufacture of many of its components.

Main sub-contractors were as follow :

Transducer measuring elements .	Elliott Bros. (London), Limited.
Potentiometric bridge units .	Bristol Instrument Company.
Speedometers	Smiths Industrial Instruments Limited.
Car heater	Joseph Lucas (gas-turbine equipment) Limited.
Portable laboratory instruments .	New Electronic Products Limited. S.F.I.N. (Great Britain) Limited
Generating set	R.A. Lister Co. Limited.
Telephone equipment	Standard Telephone & Cables Limited.
Distance counter drive.	Crofts (Engineers) Limited.
Gauges	Budenburgh Gauge Co. Limited. - Negretti & Zambra Limit.
Battery	Chloride Batteries Limited.
Battery charger	Legg Industries Limited.
Magnetic counters	Lancashire Dynamo Electronic Products Limited.
Immersion heaters . . .	Heatrae Limited.

[**621** .131 .3 (42)]

Controlled road testing system.

Procedure evolved by British Railways for assessment of locomotive performance under normal running conditions.

(*The Railway Gazette*, May 19, 1961.)

An essential requirement of traffic staff in the compiling of passenger and freight train schedules is an accurate assessment of locomotive and rolling-stock performance under normal route conditions.

For maximum operating economy this assessment must show, in a form readily usable by operating personnel, the optimum speed and performance of any locomotive under the varying route conditions of load, gradients, and distance between check-points. Conversely, it must indicate the most suitable locomotive required to maintain timings over specified routes with maximum loading conditions.

Standardised use.

To produce quickly this accurate assessment of performance the controlled road testing system has been evolved by the Research & Development (Rolling Stock) Department of Swindon Works, and is now in use by all testing organisations of British Railways.

The controlled road testing system dispenses with braking units and employs a normal train running in the usual variable speed manner over normal routes. The fundamental difference between the two systems is that constant speed testing with braking units operates under the third law of motion while the controlled road testing system operates under the second law, which is the general equation of motion of a train.

Fuel consumption control.

In the controlled road system, control is exercised over the rate at which the working medium is used by the power unit, e.g., steam in steam locomotives and fuel oil in Diesel locomotives. When this rate is constant or is a function only of train speed, actual drawbar effort/train speed relation is uniquely defined and self-compensating for gradient effect.

For steam locomotives, necessary control is effected by using a specially-developed flow indicator, but in Diesel locomotives it is even more readily obtained by placing the power controller in a pre-selected position where it must remain for the duration of the comparatively short test period required to cover the speed range.

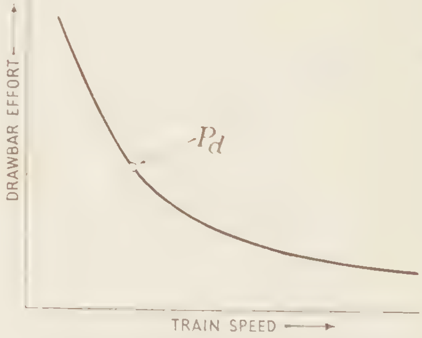


Fig. 1

Altering the load for various rates of working provides all the flexibility required and the necessary fuel consumption can be readily determined by recording and integrating units of consumption produced by positive fuel meters. The actual drawbar effort/train speed relation, as curve P_d in figure 1 above, may therefore be automatically produced on Cartesian co-ordinates by an XY recorder, and readily where electronic and potentiometric methods are available for the speed function.

Again, by these methods, acceleration can be measured accurately, making possible the production of the accelerating force per unit mass — train/speed relation, as curve A in figure 2, on Cartesian co-ordinates by another XY recorder. Compensation for the gradient effect must be introduced but, with the methods available, this presents no difficulty when a running indication of gradient is provided.

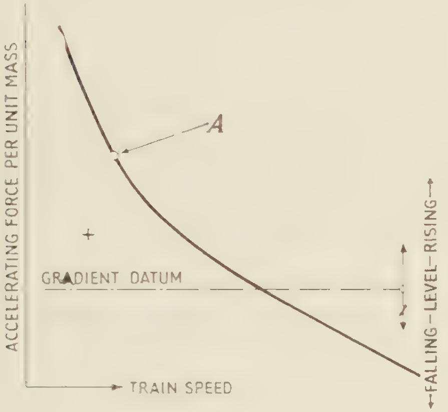


Fig. 2

Train resistance curve.

When values measured from the gradient datum of curve A are subtracted from those of curve P_d (in consistent units), as shown in figure 3, the ordinates of the resulting curve, as R_c in this figure, represent train resistance on level track in the same units. Multiplying values from curve A, measured from the gradient datum, by the locomotive mass, and adding the resulting values to curve P_d, curve P_e of figure 3 is produced, this representing the « equivalent » drawbar tractive effort on the level which is independent of train-load.

Tractive effort curve.

If the whole process be repeated when propelling the locomotive, which has its final drives disconnected for the purpose, what was the train resistance becomes the locomotive resistance on the level, R_L. By adding this to curve P_e the tractive effort at the rail is obtained, as shown by curve P_r in figure 3.

The system provides a valuable verification of the accelerating force/train speed relation where a separate recording, on suitable scales, of train speed on a distance or time base is included in the facilities provided in the dynamometer car. From the accelerating force/train speed curve and the known gradient conditions, the speed/distance curve can obviously be calculated, and if calculated and recorded curves agree, the accelerating force/train speed relation as recorded is uniquely verified.

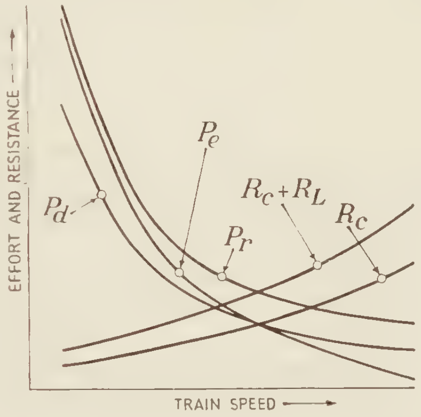


Fig. 3

The provision of the above facilities largely determines the layout of the traction console. Though a master running record of all the principal functions is still a necessity, this record may be reduced to include little more than the prime functions, making relatively large scales possible within a camparatively narrow band of paper.

Movement of band

The band moves at 1 ft. per mile when on a distance base, but it may move entirely on a time base or change automatically from a distance to a time base when train speed falls below a predetermined value and back again when speed regains this value.

The Swindon dynamometer car described in the preceding article has been designed to obtain performance characteristics with this system.

[625 .144 .3]

The paraclotoide, a new type of transition curve,

by Prof. Ing. Giovanni Polsoni.

(*Ingegneria Ferroviaria*, n° 12, December 1960.)

SUMMARY. — *Departing from an approximate examination of the clotoide, the well known transition curve also known as « spiral radioide » in contrast ot the better known cubic parabola which is also known as « abscissa radioide », the author examines the possibility of replacing the clotoide by a curve of the third degree provided that its developed length is equal to that of the clotoide, that its chord subtended between the tangent point on the straight and the tangent point on the circular curve has the same value, and that the angles between the curve and its chord at each tangent point are equal.*

In this way, when setting out a new line, it should be possible to set out a transition curve which will require little subsequent correction — though, in the author's opinion, there will never be a transition curve which, having been corrected by inspector A, will not be found to be at fault by inspector B.

1. It is common knowledge that, to compensate the centrifugal force in a curve, at least to a great part which leaves but a small excess, it is usual for the outer rail to be superelevated in the curve proper by a maximum amount h, which is not applied abruptly but is gradually attained at a linear rate over the length of the transition curve where the curvature $\frac{1}{\rho}$ varies from zero to $\frac{1}{R}$ while the superelevation varies continuously from 0 to h.

To justify the use of the well-known cubic equation of the transition curve :

$$y = \frac{x^3}{6\,R\,L}$$

it is assumed that the alignment of the transition curve is so close to the tangent at the origin that it merges with the abscissa in regard to the tangent at the end of the transition curve, since the approximate equation of the curve :

$$\frac{1}{\rho} = \frac{d^2 y}{d x^2}$$

is used in lieu of the exact equation :

$$\frac{1}{\rho} = \frac{\dfrac{d^2 y}{d x^2}}{\left\{1 + \left(\dfrac{dy}{dx}\right)^2\right\}^{3/2}} = y'' \cos^3 \theta,$$

where θ is the inclination of the geometrical tangent of the curve $y\ (x)$ on the x axis :

$$\theta = \text{arc tg} = y' \qquad \frac{dy}{dx}\,.$$

However, because of the approximations referred to above, one has not obtained, at the end of the transition curve

$$y = \frac{x^3}{6\,R\,L}$$

the curvature $\frac{1}{R}$ but a smaller curvature; i.e., the radius is not yet R but slightly greater. In a sense, the cubic transition curve has been abandoned slightly too early; when following the curve, the radius continues to decrease, and it is logical to assume that the exact value of R is encountered at a point just beyond the abscissa $x = L$.

This inaccuracy might be obviated by extended parabolic transition curves but, to my knowledge, this solution has never been pursued.

2. We may now examine the « clotoide », i.e. the classic « spiral radioide », a curve defined by its radius being a function of the development of its arc, counted from its point of origin.

As the final superelevation h is proportional to the final curvature $\frac{1}{R}$, the intermediate superelevations of the transition curve are proportional to the intermediate curvatures $\frac{1}{\rho}$, i.e.

$$h = \frac{k}{R}; \quad \frac{h\,s}{L} = \frac{k}{\rho},$$

hence $k = h\,R$, and thus :

$$\frac{1}{\rho} = \frac{h\,s}{L\,k} = \frac{s}{L\,R}$$

and $$\boxed{L\,R = s\,\rho}$$

which is known as the clotoide equation. In this formula, L is the length of the transition curve at the end of which the radius R is attained or, in other words, at the end of which the circular curve commences; s is the arc measured on the transition curve from its point of origin, i.e. from the tangent point, at the end of which the curvature is $\frac{1}{\rho}$ and the radius ρ. The curve is known as « spiral radioide » as it links the radii with the arcs.

It may be recalled that the curvature, in geometrical language, is the specific rotation in relation to the length of the arc. If the curvature is variable, one obtains, in differential terms,

$$\frac{1}{\rho} = \frac{d\,\theta}{d\,s},$$

where $d\,\theta$ is the relative rotation of the sections limiting the arc $d\,s$. It follows that :

$$d\,\theta = \frac{1}{\rho}\,d\,s \quad \text{and} \quad \theta_0^s = \int_0^s \frac{1}{\rho}\,d\,s$$

and, recalling the clotoide equation for which :

$$\frac{1}{\rho} = \frac{s}{R\,L}$$

$$\boxed{\theta_0^s = \frac{1}{R\,L}\int_0^s s\,d\,s = \frac{1}{2\,R\,L}\,s^2 = \frac{1}{2}\,\frac{s}{\rho}}$$

This is known as the « angular equation of the clotoide ».

But at any point of the cartesian system of coordinates y, x (where x follows the tangent at the origin of the transition curve, i.e. the previous straight alignment) where the differential element $d\,s$ of the transition curve forms the angle θ with the x axis, one obtains :

$$d\,y = d\,s\,\sin\theta, \quad \text{and} \quad d\,x = d\,s\,\cos\theta;$$

and therefore, by integrating to the end of the arc s, always measured along the transition curve from its origin, one obtains :

$$y\,(s) = \int_0^s \sin\,\theta\,d\,s \quad \text{and} \quad x\,(s) = \int_0^s \cos\,\theta\,d\,s,$$

These are called the « parametric equations of the clotoide », as they furnish, the coordinates y and x as functions of the arc s.

Since θ, as is apparent from the typical angular equation :

$$\theta = \frac{s^2}{2\,R\,L},$$

is definitely a positive angle, it can be defined as a positive multiple of $\frac{\pi}{2}$, by substituting :

$$\theta = \frac{\pi}{2}\, v^2.$$

Hence :

$$\theta = \frac{\pi}{2}\, v^2 = \frac{1}{2}\,\frac{s^2}{\mathrm{R\,L}},$$

and

$$\pi\, v^2 = \frac{s^2}{\mathrm{R\,L}} \text{ and } s = \sqrt{\mathrm{R\,L}\,\pi}\cdot v,$$

hence :

$$d\,s = \sqrt{\mathrm{R\,L}\,\pi}\; d\,v$$

and finally :

$$\left\{ \begin{aligned} y &= \sqrt{\mathrm{R\,L}\,\pi} \int_o^s \sin\frac{\pi}{2}\, v^2\, dv; \\ x &= \sqrt{\mathrm{R\,L}\,\pi} \int_o^s \cos\frac{\pi}{2}\, v^2\, dv, \end{aligned} \right.$$

which are the classic equations of the clotoide.

The maximum value of v occurs at the end of the transition curve and, as can easily be verified, is equal to :

$$\sqrt{\frac{\mathrm{L}}{\mathrm{R}\pi}},$$

i.e. equal to the square root of the ratio of the length of the transition curve and the half-circle of the radius R.

This means that, with railway transition curves, a small initial section of the generic curve of the clotoide is used.

It is therefore permissible to resort to an approximation by developing the sine and cosine progressions, and limiting this development of the first two terms.

One finally obtains :

$$\left\{ \begin{aligned} y &= \frac{s^3}{6\,\mathrm{R\,L}} \left(1 - \frac{s^4}{56\,\mathrm{R}^2\,\mathrm{L}^2}\right); \\ x &= s\left(1 - \frac{s^4}{40\,\mathrm{R}^2\,\mathrm{L}^2}\right). \end{aligned} \right.$$

These equations yield the cartesian coordinates at the end of the transition curve where the radius is R, and where the developed length is :

$$\mathrm{L} = \frac{h}{i}$$

(where *h* is the superelevation in the curve proper and *i* the gradient adopted for the transition curve L in order to attain the maximum superelevation *h* at a linear rate).

$$y_\mathrm{L} = \frac{\mathrm{L}^2}{6\,\mathrm{R}} \left(1 - \frac{\mathrm{L}^2}{56\,\mathrm{R}^2}\right);$$

$$x_\mathrm{L} = \mathrm{L} \left(1 - \frac{\mathrm{L}^2}{40\,\mathrm{R}^2}\right).$$

It is not easy to eliminate the parameter s from the parametric equations given above so as to obtain the value of y corresponding to any abscissa x. But it would be possible to produce a table of y and x for the different values of the parameter concerned. To obtain a value of x not included in the table, it would then be necessary to interpolate.

In practice, it is convenient to establish the end of the transition curve and to replace it, for the time being, by its cbord in view of the fact that the transition curve is closer to its chord than to its tangent at the origin. It is for this reason that we would prefer, and propose, to establish the progressive transition curve by taking as abscissae the distances measured on the chord, which will be indicated by the symbol ξ in order to distinguish them from the distances measured on the tangent (fig. 1); similarly, the ordinates in respect of the chord will be indicated by the symbol η.

The chord forms with the tangent an angle β, and one obtains :

$$\mathrm{tg}\,\beta = \frac{y_\mathrm{L}}{x_\mathrm{L}} = \frac{\mathrm{L}^2}{6\,\mathrm{R\,L}} = \frac{1 - \dfrac{\mathrm{L}^2}{56\,\mathrm{R}^2}}{1 - \dfrac{\mathrm{L}^2}{40\,\mathrm{R}^2}}$$

$$= \frac{\mathrm{L}}{6\,\mathrm{R}} \left(1 + \frac{1}{140}\,\frac{\mathrm{L}^2}{\mathrm{R}^2}\right).$$

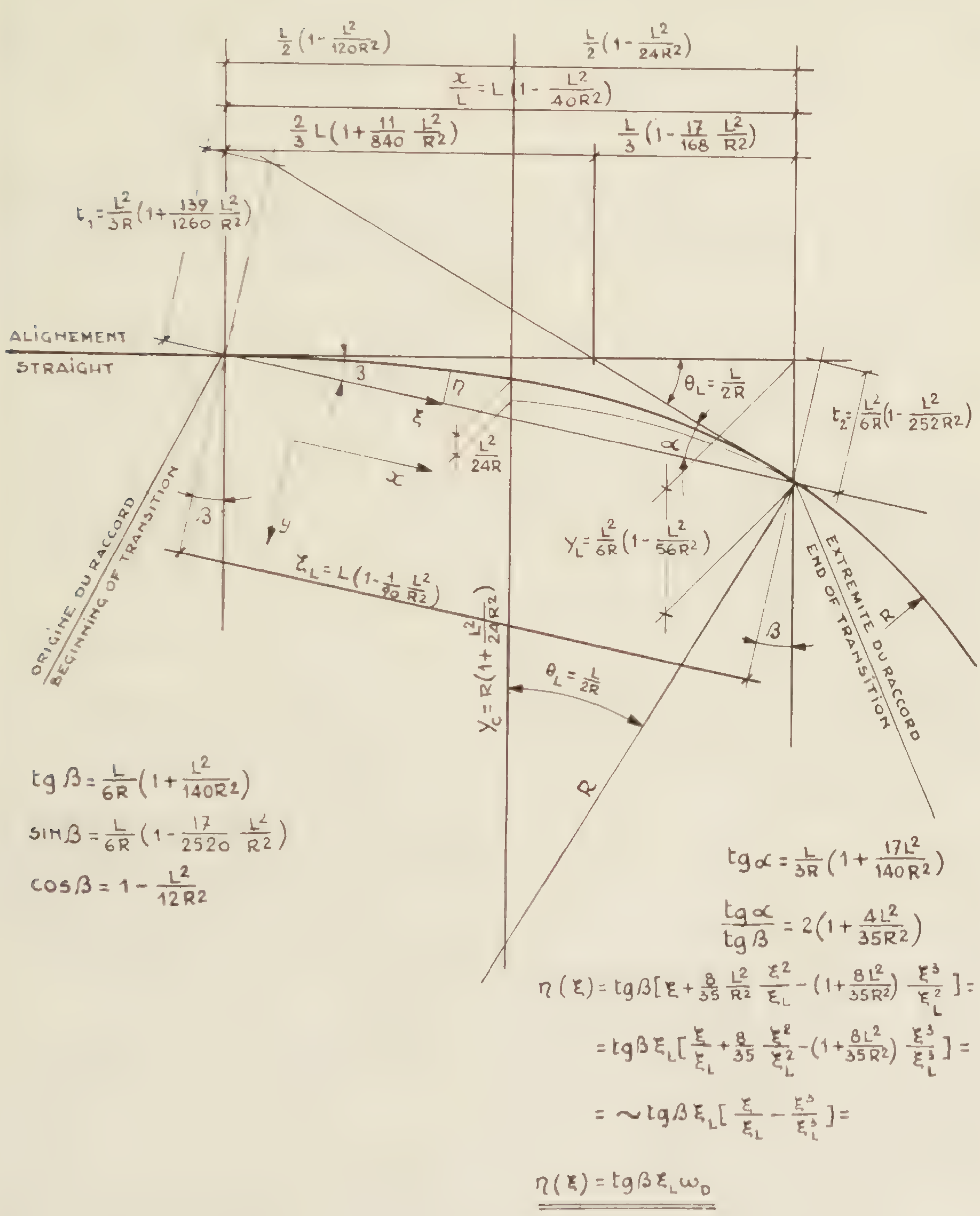

$\frac{L}{2}\left(1-\frac{L^2}{120R^2}\right)$
$\frac{L}{2}\left(1-\frac{L^2}{24R^2}\right)$
$\frac{x}{L} = L\left(1-\frac{L^2}{40R^2}\right)$
$\frac{2}{3}L\left(1+\frac{11}{840}\frac{L^2}{R^2}\right)$
$\frac{L}{3}\left(1-\frac{17}{168}\frac{L^2}{R^2}\right)$
$t_1=\frac{L^2}{3R}\left(1+\frac{139}{1260}\frac{L^2}{R^2}\right)$
ALIGNEMENT
STRAIGHT
β
η
ξ
x
$\frac{L^2}{24R}$
$\theta_L=\frac{L}{2R}$
$t_2=\frac{L^2}{6R}\left(1-\frac{L^2}{252R^2}\right)$
α
y
β
$Y_L=\frac{L^2}{6R}\left(1-\frac{L^2}{56R^2}\right)$
ORIGINE DU RACCORD
BEGINNING OF TRANSITION
$\xi_L=L\left(1-\frac{1}{90}\frac{L^2}{R^2}\right)$
$Y_c=R\left(1+\frac{L^2}{24R^2}\right)$
$\theta_L=\frac{L}{2R}$
β
EXTREMITE DU RACCORD
END OF TRANSITION
R
R
$\operatorname{tg}\beta=\frac{L}{6R}\left(1+\frac{L^2}{140R^2}\right)$
$\sin\beta=\frac{L}{6R}\left(1-\frac{17}{2520}\frac{L^2}{R^2}\right)$
$\cos\beta=1-\frac{L^2}{12R^2}$
$\operatorname{tg}\alpha=\frac{L}{3R}\left(1+\frac{17L^2}{140R^2}\right)$
$\frac{\operatorname{tg}\alpha}{\operatorname{tg}\beta}=2\left(1+\frac{4L^2}{35R^2}\right)$
$\eta(\xi)=\operatorname{tg}\beta\left[\xi+\frac{8}{35}\frac{L^2}{R^2}\frac{\xi^2}{\xi_L}-\left(1+\frac{8L^2}{35R^2}\right)\frac{\xi^3}{\xi_L^2}\right]=$
$=\operatorname{tg}\beta\,\xi_L\left[\frac{\xi}{\xi_L}+\frac{8}{35}\frac{\xi^2}{\xi_L^2}-\left(1+\frac{8L^2}{35R^2}\right)\frac{\xi^3}{\xi_L^3}\right]=$
$=\sim\operatorname{tg}\beta\,\xi_L\left[\frac{\xi}{\xi_L}-\frac{\xi^3}{\xi_L^3}\right]=$
$\underline{\underline{\eta(\xi)=\operatorname{tg}\beta\,\xi_L\,\omega_D}}$

Fig. 1.

With the aid of the trigonometric relationships, one then obtains :

$$\sin \beta = \frac{L}{6\,R}\left(1 - \frac{17}{2520}\,\frac{L^2}{R^2}\right);$$

$$\cos \beta = 1 - \frac{1}{72}\,\frac{L^2}{R^2}$$

The length of the chord of the transition curve L, i.e. ξ_L can then be worked out from :

$$\frac{x_L}{\cos\,\beta} = L\left(1 - \frac{L^2}{40\,R^2}\right)\left(1 + \frac{1}{72}\right)\frac{L^2}{R^2}$$

$$L\left(1 - \frac{1}{90}\,\frac{L^2}{R^2}\right).$$

As has already been stated, the chord is closer to the transition curve than is the tangent at its origin. The value of ξ_L can also be obtained from the equation :

$$\xi_1 \quad \frac{y_L}{\sin\,\beta}.$$

The geometric tangent at the end of the transition curve meets the geometric tangent at the origin at a point distant from the end x_L of section $\frac{y_L}{\text{tg}\,\theta_L}$ and, since

$$\theta_L = \frac{L}{2\,R}, \quad \text{tg}\,\theta_1 = \frac{L}{2\,R}\left(1 + \frac{1}{12}\,\frac{L^2}{R^2}\right);$$

one obtains :

$$\frac{y_1}{\text{tg}\,\theta_L} \quad \frac{L^2}{6\,R}\,\frac{2\,R}{L}\left(1 - \frac{L^2}{56\,R^2}\right)\left(1 - \frac{L^2}{12\,R^2}\right)$$

$$= \frac{L}{3}\left(1 - \frac{17}{168}\,\frac{L^2}{R^2}\right).$$

The complementary portion of this subtangent is :

$$\frac{2\,L}{3}\left(1 + \frac{11}{840}\,\frac{L^2}{R^2}\right).$$

The two geometrical tangents at the beginning and at the end of the transition curve intersect in such a way as to form two similar triangles whose similarity ratio is equal to :

$$2\left(1 + \frac{4}{35}\,\frac{L^2}{R^2}\right).$$

This is also the ratio of the segments intercepted between the chord and the geometrical tangents at the beginning and end of the transition curve which we shall call t_1 and t_2, respectively.

Hence :

$$t_1 = \frac{L^2}{3\,R}\left(1 + \frac{139}{1260}\,\frac{L^2}{R^2}\right);$$

$$t_2 = \frac{L^2}{6\,R}\left(1 - \frac{1}{252}\,\frac{L^2}{R^2}\right);$$

and :

$$\frac{\text{tg}\,\alpha}{\text{tg}\,\beta} = 2\left(1 + \frac{4}{35}\,\frac{L^2}{R^2}\right)$$

and $$\text{tg}\,\alpha = \frac{L}{3\,R}\left(1 + \frac{17}{140}\,\frac{L^2}{R^2}\right).$$

It follows that the subtangent of the approximate clotoide, based on the first two terms of the development of the sin θ and cos θ progressions, corresponds to about one third of the entire length of the transition curve, and that the intercepted sections of the geometrical tangents at the ends t_1 and t_2 are, very approximately, in the proportion of 2 to 1. In the circumstances, the transition curve could be replaced by an equation of the third degree related to the chord, of the following type :

$$\zeta = \text{tg}\,\beta\,\xi_1\left(\frac{\xi}{\xi_L} - \frac{\xi^3}{\xi^3{}_L}\right) = \text{tg}\,\beta\,\xi_1\,\omega_D.$$

where $\omega_D = \frac{\xi}{\xi_L} - \frac{\xi^3}{\xi^3{}_L}$.

We intend to express, by way of approximation, the clotoide curve so far considered by an algebraic equation of the third degree, related to the chord of the transition curve, having the same point of origin, i.e. at the tangent point, and ending at the end of the chord. The length of the chord, which forms the angle β with the geometric tangent at the origin, is thus :

$$\xi_L = L\left(1 - \frac{1}{90}\,\frac{L^2}{R^2}\right).$$

The curve $\eta\ (\xi)$ will be of the type $\eta = b\,\xi + c\,\xi^2 + d\,\xi^3$ and the marginal condition will be $\eta_{\xi=0} = \eta_{\xi=L}$. The first condition is easily verified, and the second condition yields : $\xi\,c + \xi^2_L\,d = -\,b$.

Moreover, the trigonometric tangent of the angle between the geometric tangent at the origin and the ξ axis must be equal to tan β whilst the corresponding angle at the end of the transition curve must be equal to $-\ \mathrm{tg}\ \alpha$.

The first condition yields $b = \mathrm{tg}\ \beta$ so that $\eta' = b + 2\,c\,\xi + 3\,d\,\xi^3$ becomes $\eta' = \mathrm{tg}\ \beta + 2\,c\,\xi + 3\,d\,\xi^2$, whilst the second condition yields :

$$2\,\xi_L\,c + 3\,\xi^2\,d = -\,\mathrm{tg}\ a - \mathrm{tg}\ \beta.$$

The constants c and d are given by the system :

$$\begin{cases} \xi_L\,c + \xi^2_L\,d = -\,\mathrm{tg}\ \beta; \\ 2\,\xi_L\,c + 3\,\xi^2\,d = -\,(\mathrm{tg}\ \alpha + \mathrm{tg}\ \beta); \end{cases}$$

If these equations are solved, they enable us to write the third-degree equation $\eta\ (\xi)$, which approximates the equation of the clotoide found earlier :

$$\eta = \mathrm{tg}\ \beta\left\{\xi + \frac{8}{35}\,\frac{L^2}{R^2}\,\frac{\xi^2}{\xi_L} - \left(1 + \frac{8}{35}\,\frac{L^2}{R^2}\right)\frac{\xi^3}{\xi^2_L}\right\};$$

$$= \mathrm{tg}\beta\,\xi_L\left\{\frac{\xi}{\xi_L} + \frac{8}{35}\,\frac{L^2}{R^2}\,\frac{\xi^2}{\xi^2_L} - \left(1 + \frac{8}{35}\,\frac{L^2}{R^2}\right)\frac{\xi^3}{\xi^3_L}\right\}.$$

The corrective factor $\frac{8}{35}\,\frac{L^2}{R^2}$ has little significance. For an extreme case of $h = 0.14$ m, $L = 140$ m, $R = 400$ m, the value of this factor is :

$$\frac{8}{35}\,\frac{L^2}{R^2} = 28\ ^0/_{00}$$

and can therefore be neglected in a first approximation curve.

One thus obtains :

$$\eta \simeq \mathrm{tg}\ \beta\ \xi\left(\frac{\xi}{\xi_L} - \frac{\xi^3}{\xi^3_L}\right) = \mathrm{tg}\ \beta\ \xi_L\ \omega_D,$$

In view of its origin, this curve may well be called « paraclotoide ».

It is known that :

$$\mathrm{tg}\ \beta = \frac{L}{6\,R}\left(1 + \frac{1}{140}\,\frac{L^2}{R^2}\right)$$

and
$$\xi_L = L\left(1 - \frac{1}{90}\,\frac{L^2}{R^2}\right).$$

The values of :

$$\omega_D = \frac{\xi}{\xi_L} - \frac{\xi^3}{\xi^3_L}$$

are given in numerous tables in the technical literature. It is, in any case, easy to prepare a table on one's own if a table of the cubes of the natural numbers is available. If the chord is divided into ten parts, the values of ω_D will be :

$$\frac{1}{10} - \frac{1}{1000};\quad \frac{2}{10} - \frac{8}{1000};\quad \frac{3}{10} - \frac{27}{1000}$$

etc.

Numerical example.

The transition curve to the circular curve of radius R, suggested by the author and named « paraclotoide » as it must be assimilated to the « spiral radioide » known as clotoide, has been related (cf. fig. 2) no longer to the straight alignment preceding the circular curve, but to the chord of the clotoide, and is calculated as an algebraic curve of the third degree having the same initial inclination β, final inclination α, and development L, as the clotoide. The ordinate η on the chord of this algebraic substitute for the clotoide is therefore defined by the following equation for ξ, where the abscissae are taken on the chord :

$$\eta(\xi)=\mathrm{tg}\ \beta\left\{\xi+\frac{8}{35}\,\frac{L^2}{R^2}\,\frac{\xi^2}{\xi_L}-\left(1+\frac{8}{35}\,\frac{L^2}{R^2}\right)\frac{\xi^3}{\xi^2{}_L}\right\};$$

and, taking into consideration the length ξ_L of the clotoide chord :

$$\eta(\xi)=\mathrm{tg}\ \beta\ \xi_L\left\{\frac{\xi}{\xi_L}+\frac{8}{35}\,\frac{L^2}{R^2}\,\frac{\xi^2}{\xi^2{}_L}-\left(1+\frac{8}{35}\,\frac{L^2}{R^2}\right)\frac{\xi^3}{\xi^3{}_L}\right\},$$

which may also be written as follows :

$$\eta(\xi)=\mathrm{tg}\ \beta\ \xi_L\left\{\left(\frac{\xi}{\xi_L}-\frac{\xi^3}{\xi^3{}_L}\right)+\frac{8}{35}\,\frac{L^2}{R^2}\left(\frac{\xi^2}{\xi^2{}_L}-\frac{\xi^3}{\xi^3{}_L}\right)\right\}$$

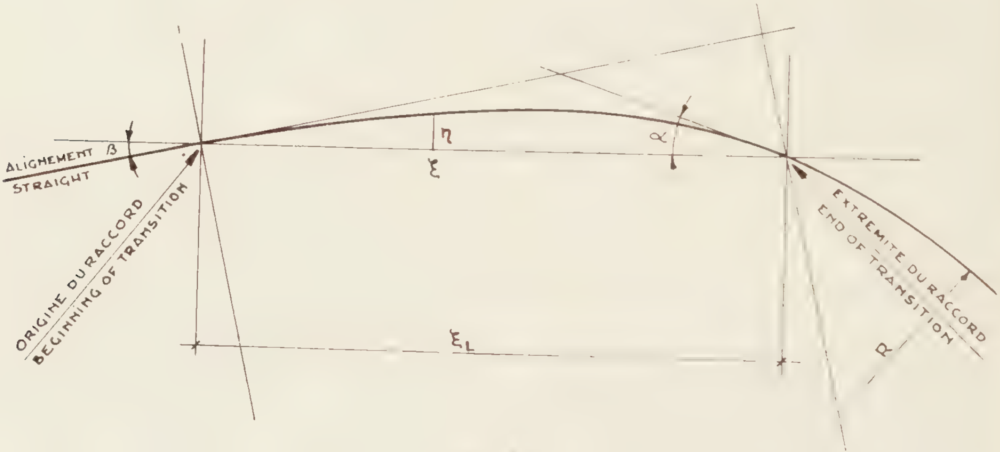


Fig. 2.

If the terms in brackets

$$\left(\frac{\xi}{\xi_L}-\frac{\xi^3}{\xi^3{}_1}\right)\ \text{and}\ \left(\frac{\xi^2}{\xi_1}-\frac{\xi^3}{\xi^3{}_1}\right)$$

are taken from, e.g. Müller-Breslau, *Scienza delle Costruzioni*, Edition Hoepli, Vol. III, p. 42, and if these are denoted by the symbols ω_D and $\omega_D - \omega_R$, where :

$$\omega_D=\frac{\xi}{\xi_L}-\frac{\xi^3}{\xi^3{}_L}\quad\text{and}\quad\omega_R=\frac{\xi}{\xi_L}-\frac{\xi^2}{\xi^2{}_1};$$

one obtains :

$$\eta(\xi)=\mathrm{tg}\ \beta\ \xi_L\ \omega_D+\mathrm{tg}\ \beta\ \xi_L\,\frac{8}{35}\,\frac{L^2}{R^2}\,(\omega_D-\omega_R).$$

The coefficients ω_D and ω_R, which are purely numerical and dimension-less, are extensively tabulated in the book named above.

The term η (ξ) would be monomial and equal to tg β ξ_L ω_D if the factor :

$$\frac{8}{35}\,\frac{L^2}{R^2}$$

is very small which happens if L is very small and R very great. But L, i.e. the length of the transition curve, depends on the maximum superelevation *h*, and on the gradient *i* by which this superelevation is attained along the transition curve. In view of the tendency towards higher speeds, it is clear that the superelevation normally adopted will be the maximum cant of $h = 0.160$ m so that, with a gradient of $i = 1$ in 1000 adopted for attaining this superelevation, the length of the transition curve becomes L = 160 m. (Smaller values can be obtained by adopting a steeper gradient, or for cants below the maximum of $h < 0.160$ m, i.e. for lower speeds.)

To take, by way of example, an unfavourable case, let L be 160 m and R = 400 m. In this case, the maximum permissible speed, corresponding to a non-compensated centripetal acceleration of $a = 0.6$ m/sec^{-2}, is obtained from the equation :

$$V_{max} = 4{,}619\sqrt{R},$$

which yields :

$$V_{max} = 92{,}380 \text{ km h}^{-1}.$$

The official speed limit to be indicated on the line and in the running charts will then have to be : $V_{max} = 90$ km/h.

We can now deal with our transition curve.

$$\frac{L}{R} = \frac{160}{400} = 0{,}4; \quad \frac{L^2}{R^2} = 0{,}16.$$

To enable the chord of the transition curve to be set out in relation to the tangent, which is a typically topographical operation, it is necessary to know the angle β between the chord of the transition curve and the straight alignment :

$$\text{tg } \beta = \frac{L}{6R}\left(1 + \frac{1}{140}\frac{L^2}{R^2}\right) = \frac{0{,}4}{6}\left(1 + \frac{0{,}16}{140}\right)$$

$$= 0{,}066666 \times 1{,}00114286 = 0{,}066743;$$

$$\beta = 13746'' = 3^\circ 49' 6''.$$

We are thus able to set out the chord of the paraclotoide. The length of the chord is derived from the following equation :

$$\xi_L = \frac{X_L}{\cos \beta} \text{ where } X_L = L\left(1 - \frac{L^2}{40\,R^2}\right)$$

$$= 160\left(1 - \frac{0{,}16}{40}\right) = 159{,}360 \text{ m}$$

and, with $1/\cos \beta = 1.002225$,

$$\xi_L = 159{,}360 \times 1{,}002225 = 159{,}715 \text{ m}.$$

With these data, we are also able to find :

$$\text{tg } \beta\, \xi_L = 0{,}066743 \times 159{,}715 = 10{,}660 \text{ m};$$

$$\frac{8}{35}\,\frac{L^2}{R^2} = \frac{8}{35}0{,}16 = 0{,}036571;$$

and hence :

$$\underline{\eta(\xi) = \text{tg } \beta\, \xi_L \left\{\omega_D + 0{,}036571\,(\omega_D - \omega_R)\right\} =}$$

$$\underline{= 10{,}6600\,\omega_D + 0{,}3898\,(\omega_D - \omega_R).}$$

With the aid of this equation, we calculate the value of $\eta(\xi)$ at 16 equidistant points on the chord ξ, the spacing being :

$$\frac{159{,}715}{16} = 9{,}9822 \text{ m}.$$

For the further calculation, it is necessary to know the angular coefficients at the 16 points of the paraclotoide and the derived function η'' so that the exact curvature of the equation :

$$\frac{1}{\rho} = \eta'' \cos^3 \varphi.$$

can be obtained.

The above equation for $\eta(\xi)$ yields :

$$\text{tg } \varphi = \eta'(\xi) = \text{tg } \beta \left\{1 + \frac{16}{35}\,\frac{L^2}{R^2}\,\frac{\xi}{\xi_L} - 3\left(1 + \frac{8}{35}\,\frac{L^2}{R^2}\right)\frac{\xi^2}{\xi^2_L}\right\}$$

and, numerically,

$$\text{tg } \varphi = 0{,}066743 + 0{,}004882\frac{\xi}{\xi_L} - 0{,}207552\frac{\xi^2}{\xi^2_L};$$

while :

$$\eta''(\xi) = \frac{\text{tg } \beta}{\xi_L}\left\{\frac{16}{35}\,\frac{L^2}{R^2} - 6\left(1 + \frac{8}{35}\,\frac{L^2}{R^2}\right)\frac{\xi}{\xi_L}\right\},$$

or, numerically,

$$\underline{\eta''(\xi) = 0{,}00003056 - 0{,}002999\frac{\xi}{\xi_L}.}$$

It is frankly admitted that the paraclotoide is slightly inaccurate at the origin since, at that point, one should obtain $\eta''(0) = 0$, since $\cos^3 \varphi$ at this point is not $\varphi = 0$. As we shall presently see, there occurs a very slight counter-curve. For the present, we can proceed with the calculation of the curvatures at some specific points so that we can compare them with those of the true clotoide.

To calculate the progressive developments s of the paraclotoide, we could use the « Simpson 1/3 » integration of the function $1/\cos \varphi$, since :

$$d\,s = \frac{d\,\xi}{\cos \varphi} \text{ and } s = \int \frac{d\,\xi}{\cos \varphi} \simeq \frac{\Delta\,\xi}{3} \sum_{\text{Simpson}} \frac{1}{\cos \varphi}$$

TABLE I.

	1	2	3	4	5	6	7	8
	η	$\eta' = \mathrm{tg}\,\varphi$	η''	$\cos^3 \varphi$	$\frac{1}{\rho} = \eta'' \cos^3 \varphi$	$1/\cos \varphi$	$s = \int \frac{d\xi}{\cos \varphi}$	$1/\rho$
						1,002.147		
0	0,0000	0,066.743	+ 0,000.03056	0,993.355	0,000.03036	1,002.225	0,0000	0,000.000
1	0,6651	0,066.237	— 0,000.1319	0,993.455	0,000.1310	1,002.191	10,0040	0,000.1563
2	1,3170	0,064.110	— 0,000.2943	0,993.866	0,000.2925	1,002.053	20,0071	0,000.3126
3	1,9396	0,060.362	— 0,000.4567	0,994.562	0,000.4542	1,001.819	30,0083	0,000.4688
4	2,5167	0,054.991	— 0,000.6192	0,995.482	0,000.6164	1,001.510	40,0068	0,000.6251
5	3,0321	0,048.000	— 0,000.7816	0,996.554	0,000.7788	1,001.151	50,0019	0,000.7812
6	3,4696	0,039.387	— 0,000.9441	0,997.677	0,000.9419	1,000.776	59,9933	0,000.9373
7	3,8130	0,029.152	— 0,001.1065	0,998.727	0,001.1051	1,000.424	69,9811	0,001.0934
8	4,0462	0,017.296	— 0,001.2689	0,999.552	0,001.2683	1,000.149	79,9657	0,001.2494
9	4,1530	0,003.807	— 0,001.4314	0,999.979	0,001.4314	1,000.007	89,9482	0,001.4053
10	4,1171	— 0,011.281	— 0,001.5938	0,999.809	0,001.5935	1,000.064	99,9302	0,001.5613
11	3,9323	— 0,028.001	— 0,001.7562	0,998.826	0,001.7541	1,000.391	109,9140	0,001.7172
12	3,5526	— 0,046.343	— 0,001.9187	0,996.787	0,001.9125	1,001.073	119,9828	0,001.8746
13	2,9917	— 0,066.307	— 0,002.081	0,993.441	0,002.0673	1,002.196	129,9005	0,002.0295
14	2,2234	— 0,087.891	— 0,002.243	0,988.523	0,002.2173	1,003.855	139,9912	0,002.1872
15	1,2316	— 0,111.098	— 0,002.406	0,981.767	0,002.3621	1,006.153	149,9432	0,002.3427
16	0,0000	— 0,135.927	— 0,002.568	0,972.912	0,002.4984	1,009.196	160,0010	0,002.500
						1,013.090		

But, having obtained an insufficiently exact result, we have finally adopted a more exact calculation. We have also tried to calculate the length of this curve by deducing the value from the elementary chords corresponding to the base $\Delta\ \xi$. But this yielded a total length of 159,9641 m instead of 160 m; the chords are in fact shorter than the arc. The result was therefore still not accurate enough.

Column 3, η'', of Table I shows the first approximation of the curvature of the paraclotoide, and it is on this first approximation that the practical method of curve correction is based. For instance, the curvature at point 3, worked out by the method of the finite differences applied to the correction of the curves, amounts to :

$$\frac{3170+2\cdot 1{,}9396-2{,}5167}{9{,}9822^2}=\frac{0{,}0455}{99{,}6443}=0{,}0004566,$$

instead of 0,0004567 (9,9822 being the interval ξ between the 16 points).

In contrast, column 5, $\eta'' \cos^3 \varphi$, shows the theoretically exact values of the curvature of the paraclotoide.

Column 7 shows the progressive developments of the paraclotoide calculated by a special method which, to avoid undue prolixity, is not explained here. The length of the paraclotoide is thus found to be 160,0010 m, compared with 160,000 m for the clotoide. It must, in any case, be remembered that the integration of the term:

$$s = \int \frac{d\,\xi}{\cos\ \varphi},$$

can at best be no more than an approximate integration, even if the calculation is based on the most exact method.

On the assumption that the successive values s of the partial lengths of the transition curve are valid, the curvature values have been calculated proportionately to them. In the last column (8), these values correspond to the definition of the clotoide. At the origin itself, a counter-curvature of 32,938 m radius is observed. At certain intermediate points, the curvature of the paraclotoide is liable slightly to exceed that of the clotoide or, more often, to be slightly short of the latter, which is not harmful. To replace the clotoide by an algebraic curve, it would be necessary to raise the degree of the latter by stipulating the identity of the curvature at all points. The author has adopted a compromise solution which makes use of numerical tables which are already in being, and are well known to the Bridge Departments. It is also necessary, especially on steel bridges, on to which the transition curves of circular curves extend, to have the means of setting out the track on the bridge with a similar degree of accuracy as on the ground.

[625 .282 (43)]

The thousandth Diesel locomotive of the Deutsche Bundesbahn,

by Dr.-Eng. G.A. Gaebler.

(*Glasers Annalen*, No. 2, February 1961.)

About three months ago, at the inauguration of the Exhibition of Vehicles organised on the occasion of the 125th anniversary of the German Railways at Nuremberg, Dipl.-Ing. Geitmann, the Chairman of the Deutsche Bundesbahn, was able to present to the public the 1 000th electric locomotive of the D.B. Since then, as was announced at the time, the 1 000th Diesel locomotive has also been put into service. What could show better in a very strikingly manner than these close linked events how the future stock of locomotives of the D.B. will be based to some extent on the two modern kinds of traction, electric traction and Diesel traction ?

In itself, the putting into service of the thousandth Diesel locomotive is not an event of any special importance. But it represents a landmark on the track of the modernisation and improvement of the locomotive stock of the German Federal Railway. It shows that the change in structure bound up with modernisation — which is what we call the replacement of the worthy old steam locomotive by Diesel and electric locomotives — is moving onwards at a great pace to the benefit of a veritable rationalisation of the operating and an increase in production. But such an event is also the right time at which to cast a critical look backwards to make sure that the work of renewal embarked upon after the war was begun at the right moment and has been pursued methodically and logically.

When after the second world war, German railwaymen had to bring back to life from the ruins the once so proud Deutsche Reichsbahn a new powerful railway system, a whole series of problems of principle arose that were extremely difficult and weighty in their consequences. For the designing of the Diesel locomotives, which could only be considered some time after the monetary reform, there were well known and well tried examples abroad, particularly in the United States, in the case of heavy Diesel-electric locomotive types which are those preferred there. There were also very encouraging experiences of trial vehicles of the Diesel-hydraulic type in Germany itself. In examining the operating and power programme to be introduced in Germany in the case of Diesel locomotives of average and high powers, it was also necessary, for economic reasons, to endeavour to design powerful engines that were lighter than those known to date. It was not an easy decision at the time, for important reasons connected with the technical suitability and the economic future of the models, to project and design new types of locomotives, specially adapted for Central European use, even if this necessarily involved a certain number of technical risks. It was under these circumstances that the first prototype Diesel-hydraulic locomotives were designed in Germany, making use not only of hydrodynamic transmissions — already known in principle, but restudied from a more modern point of view — but also of faster Diesel engines, which were therefore smaller and lighter, as well as the « cardan shaft » drive which had never before been approved in the construction of locomotives. The first test model of this type of locomotive was the « V 80 » of the Deutsche Bundesbahn, which was soon followed by the more powerful twin engined type the « V 200 », which today can frequently be seen at the head of fast, heavy trains.

The present programme of types of Diesel locomotives of the Deutsche Bundesbahn only includes — apart from the « loco-tractors » — 4 types of locomotives already in service : the special shunting engine the « V 60 », the single engined Diesel locomotive for secondary lines, the « V 100 », the light single engined locomotive for main lines the « V 160 », and the twin engined locomotive for main lines the « V 200 », which is more powerful. With this modest programme of types of modern Diesel-hydraulic locomotives, probably unique in the world from the point of view of its restraint, the Deutsche Bundesbahn is in a position to meet all the traction problems which now arise upon its system. And this programme does not as yet include the heavy line Diesel locomotive with twin engines, the « V 320 », also designed by the Deutsche Bundesbahn, which will develop nearly 4 000 HP, as problems in connection with very heavy traction arise above all on the lines that have already been electrified or which are to be electrified in the future, where such powers will naturally be supplied by electric locomotives.

Moreover, this programma has so many imbrications and internal complications that it is not even possible to say that it is merely a question of 4 or 5 different types. The V 200 is in practice the twin engined version of the single engined V 100, and the V 320 will be the twin engined version of the single engined V 160. Only the shunting locomotive, the V 60, is a separate type; moreover the 5 types of locomotives are in addition also characterised by numerous interchangeable parts, which are used on all the types or on several of them.

We must not forget to point out that the Deutsche Bundesbahn, as a large railway undertaking, has to adopt the types of locomotives which are most suitable for its operating and the most economic, and for this reason alone it could not consider binding itself to hydraulic types of drive only. Technical developments in the field of construction of electric locomotives are watched with constant close care, because a modern Diesel-electric locomotive might very well compete some day with the types used to date, if it could be built and run at the same cost for the same power. For the moment such an evolution does not appear, and the Deutsche Bundesbahn can, as the Head of the Traction Department, Dr.-Eng. WIENS, Manager attached to the Central Administration, recently declared, be completely satisfied with the decision taken as regards the principle of the technical design of its Diesel-hydraulic locomotives, even when looking at it from the most difficult and critical aspect in comparison with the remarkable results obtained, abroad again, in the construction of modern locomotives. As regards future technical evolution, it should be pointed out that these types of Diesel-hydraulic locomotives not only cover the whole range from low to high power, but in their layout and equipment are being constantly improved and often, a particularly important point, simplified. Thus the moment does not appear to be far off when — like electric locomotives — the Diesel locomotives will be braked through their hydraulic transmissions. Already at the present time, the types of locomotives indicated — equipped with telecontrol — haul rakes that cannot be reversed by telecontrol. In the same way, the study of locomotives which can be operated from the line or by radio, which might be of great advantage for use in marshalling yards, for example, has already resulted in methods allowing of their operation by radio.

On this occasion, we might say something about the excellent collaboration, in their mutual interests, between industry and the railway, which alone has made it possible to obtain such thoroughly satisfactory results in this very difficult technical field. In the construction of railway vehicles, it is already of particular importance because, unlike the naval yards or motor car or aeroplane factories, the industrial firms have no lines of their own on which to carry out trials and obtain their own experience in service. In this field, the vehicle drawing offices of industry and the technical services of the Deutsche Bundesbahn, including its test laboratories, work together very closely and most successfully. Nor must we forget the pooling of experiences on the international plane, which is of the greatest importance and interests all railways, and it is interesting to see the ever growing interest in recent years in German designs of locomotives, even on the part of large foreign railway Administrations, which have very powerful nationalised industries behind them.

These notes were inspired by the fact, mentioned above, that the 1 000th Diesel locomotive of the German Federal Railway has just been put into service. The summary given in Table I will show the composition of the stock of locomotives of the Deutsche Bundesbahn. The numbers of the different types of locomotives are given, on the one hand for the pre-war and prototype test types, and on the other for the group of the 4 standard types of the D.B. The increase in numbers to be expected during the next two years by the delivery of the new Diesel locomotives for secondary lines, the V 100, will be noted. The V 160, of which there are still only a few, will probably be put into service on a much wider scale in the years to come, when the prototypes now in service and under construction have been perfected in a completely satisfactory way. Even the V 200, as can already be seen, will doubtless be followed up. Perhaps even with an installed power not very far from 3 000 HP, although the design will remain the same.

The development of the mileage worked, and correlatively, the increase in the fuel consumption, of the Diesel locomotives of the Deutsche Bundesbahn during the last few years is illustrated by a few figures in Table 2. The extraordinary increase in the mileage is particularly remarkable in this case when it is remembered that the largest stock today consists of the V 60 shunting Diesel locomotives.

Three months ago, the thousandth electric locomotive, today the thousandth Diesel locomotive of the German Federal Railway. This does not mean that there is frenzied competition between the two. On the contrary, these two events occurring so close to each other prove that the D.B. is sharing the replacement which has now become inevitable — unfortunately one is tempted to say from the point of view of the romanticism of the railway — of our steam locomotives by modern traction units, logically between the two methods of traction, the electric locomotive being con-

TABLE I. — **Present numbers and probable numbers in the next two years of the Diesel locomotives of the Deutsche Bundesbahn.**

Series	Numbers end 1960	Under order or being delivered	Numbers expected by the autumn of 1962	
V 20	30	—	30	Prewar types and prototypes
V 36	91	—	91	
V 45	10	—	10	
V 188	2	—	2	
V 65	15	—	15	
V 80	10	—	10	
V 60	731	70	801	Standard types
V 100	7	378	385	
V 160	3	7	10	
V 200	86	—	86	
	985	455	1 440	

TABLE 2.— **Comparison of the mileage and fuel consumption for Diesel locomotives in 1956, 1958 and 1960.**

Year	Numbers at the end of the year units	Mileage million km	Fuel consumption thousands of tons
1956	225	9.2	12.1
1958	532	31.87	50.6
1960	985	53.3	95.2

stantly increasing on the heavily loaded electrified lines, whilst in the future the Diesel locomotive is to serve the vast system of lines with less or little traffic. These two methods of traction are the completely rational complements to each other, the limits of their economic user being determined essentially by the load on the line upon which depends the cost of the power in the case of electric traction, and, in the case of Diesel traction, by the fuel costs which determine the power costs — and in Germany are also subject to heavy customs and import duties. It is to be hoped that here again a rational rearrangement of the incidence of taxation on shipping, railway and road users will give a new impetus to the use of Diesel locomotives.

[656 .23 (73)]

Scientific pricing is the key to increased traffic, revenue,

by Robert T. Wood. (*)

(*Railway Age*, March 27, 1961.)

How should railroad freight service be priced to attract to railroads that part of the total movement which they can handle economically, while, at the same time, railroads get the largest possible net revenue?

Some innovators would put aside « value of service » considerations and base railroad rates entirely on railroad out-of-pocket costs as a « floor » — with a « ceiling » slightly below the cost of competitive service (especially that of private transportation). Between the « ceiling » and the « floor » they would establish a rate progression at some arbitrary percentage above actual cost.

The writer of this article accepts the « floor » and the « ceiling », but he believes the actual rate progression between those two boundaries should be « tailored to fit » the marketing practices of the commodity in question.

Editor.

The heart of the discussion of railroad rate-making now raging lies in the fact that competitive and financial pressures have changed the railroads' pricing system just as the forward pass and the free substitution rule changed football. The object of the game is the same, but who uses the « flying wedge » any more? Strategy has to be different nowadays. And flexible, too.

The objective of higher net profit is not attained by raising rates across the board on a diminishing traffic volume.

Neither is that objective attained by establishing rates at a figure representing fully distributed costs plus a standard ratio of mark-up — which some have advocated.

Nor are profits often enhanced by cutting rates to the bone for carload minima that are kept down to approximate the minima of trucks — thus choosing to compete on the competitors' terms, throwing away the economy of well-filled cars — an economy that can be shared with customers, thus attracting their patronage while maximizing railroad earnings per carload.

There is a fantastic variety in the pricing problems faced by railroad rate makers, but observation seems to substantiate the following conclusions:

— The only principle of railroad rate-making that fits nearly all movements is the prescription calling for low rates — small profit margins above direct costs — on short hauls, where the competition is strongest and traffic volume the heaviest.

— An « incentive discount » can be effective (provided the resulting rate is attractive) whether it takes the form of several alternate minima or is continuous (i.e., applies to every 100 lb. above the minimum). The choice of incentive method should be heavily conditioned by the customer industry's pricing system.

(*) Robert T. Wood is a transportation research analyst having market and rate experience in industrial traffic, air and railroad transportation.

— Each railroad rate should be above direct cost and below truck cost (i.e., where the truck cost is above rail direct cost). Rate policy concerns what can be done between the floor of railroad cost and the ceiling of truck cost. That is where value-of-service considerations must be taken into account.

— The railroads' great opportunity, their great economic potential, lies in filling their half-loaded cars. This can be done by establishing low rates based on high loads where the rails do not now have the traffic, and by sharing with shippers through lower rates the savings gained by heavier loads.

— There are limits to the extent to which railroads can profitably charge high rates for the longer hauls, beyond the reach of truck competition. There is evidence that total transportation demand is often elastic at longer hauls, and that moderate rates can often create new traffic.

— A most important factor affecting the railroad traffic volume of any commodity is the industry's pricing policy — e.g., whether the receiver who buys the merchandise pays more if he requires shipment by truck when truck rates are higher than railroad rates. Although such a trade practice would seem to be outside the railroad's control, there is some evidence that efforts to provide customers with an incentive — possible and justifiable by relative economy of railroad service — will induce changes in the way the business is conducted.

Some major types of industrial pricing systems which the rate-maker must take into account in the actual construction of rates are :

1. *Delivered, destination pricing.* Under this system the shipper absorbs all freight charges. The customer pays the same for his goods whether they come by rail or by truck. The minimum quantity on which the shipper will absorb the freight charge is usually the equivalent of a truckload. Since the receiver saves no money from a railroad rate that is lower than the truck rate, and since truck service is often more convenient for the receiver, he will usually specify truck routing. A lower railroad rate is ineffective in attracting traffic to railroads where this pricing policy applies and the receiver routes the freight.

2. *Freight charges equalized via type of carrier.* Here the customer pays the price of the goods at the point of origin, plus the freight rate from the nearest competitive point of origin. If he orders from a point from which the rate to his plant is 50 cents and he could buy from another point where the applicable rate is 35 cents, he pays origin price plus 35 cents. If he specifies truck routing, he pays the truck rate from the nearest competitive point. If he specifies rail shipment, he pays the railroad rate from the nearest point of origin.

Note that in this case the rates that will determine the consignee's choice of transportation will not be the rates on the longer hauls from actual points of origin, but the rates on movement from competing points, where the haul may be shorter. However, the receiver does benefit from lower railroad rates. Hence, railroads are in a much happier situation under this type of pricing than when all freight charges are absorbed by the shipper, with choice of transportation left to the consignee.

3. *Full freight allowed, cheapest means.* Under this arrangement, the customer must order at least the minimum weight applicable to the lowest published rate, whether by rail or truck, to avoid paying freight charges. Any excess in charges above the lowest published rate is charged to his account. Here lower rates by the railroad are effective in inducing the use of railroad service.

4. *Rail freight allowed, premium charged for truck shipment.* This pricing system is often used where receivers want jobsite delivery or carefully timed delivery and will pay a premium.

5. *Negotiated delivered price.* Here the (usually) lower railroad rate is used in calculating the laid-down price at destination. Truck routing is permitted in emergencies, but the intent is that the cheapest means be used as much as possible. Where railroad rates are lower, such pricing usually results in movement by railroad.

6. *Quantity discounts above the truckload minimum.* Under this system there are lower prices for volume purchases. The lower prices for higher volumes are sometimes associated with lower freight rates at higher alternate minima, or with bulk handling and lower handling cost. Although the quantity discount applies for either rail or truck movement, when the discounts apply at higher weights, they often tend to favor movement by rails. However, the rails' advantage is nowhere near as great as under 2 or 3 above.

The accompanying case histories show examples of how industry pricing policies and other elements of the marketing situation call for varying treatment by railroads.

Compare Commodities « A », « C » and « F ». They are in the same general business type, their loading characteristics run from heavy to fairly heavy and their cost per pound is fairly low as manufactured products go. Yet in case « C » it would probably take no more than a cent per 100 lb. to win much of the traffic to rail movement. In case « A » it would take at least 5 cents to have substantial effect (more at higher weights), and in case « F » a difference of 30 cents might not be enough.

Pricing for profit. — There is a consistent pricing philosophy behind the pricing recommendations shown in connection with cases « A » through « G ». It may be summarized as follows :

if there is traffic moving by other methods for which railroad costs permit railroads to compete, then they should make rates to attract that traffic, provided the sacrifice in revenue on traffic now moving by rail is not too great. Of course, if present traffic is sharply declining, this sacrifice of present revenue is not very important.

Where customers are satisfied with service and present profitable rates, the situation should be disturbed as little as possible.

When overall pricing results in overall earnings that are unnecessarily lucrative, only then will there be justification for downward revision of rates for any other purpose than to increase net earnings. This policy is very much to the public's advantage, because only reasonably profitable railroads can attract the capital necessary to keep their service modern.

There is nothing economically or morally wrong with « charging what the traffic will bear » in the railroads' present situation. They need more money or they'll go broke. The big thing is to find out where the customer is able and willing to pay a reasonable profit margin before he turns away from the railroads to alternate forms.

In the long run there is nothing inimical to truck transportation — where comparative economy is on their side — in such an aggressive pricing policy as this on the part of railroads. Such a policy by railroads will deliberately encourage trucks to take that traffic (shorter hauls and lighter loads) where they have an economic advantage. Trucks will lose only where they have penetrated into traffic which can be handled most economically by railroads. The advantage to shippers is also perfectly clear — lower total cost of transportation by encouraging each agency to concentrate in the field of its own economic superiority. Both railroads and trucks should thrive on this approach to pricing, and that also is to shippers' advantage in assuring that both agencies have the means to keep their facilities up to date.

The way to begin to find out what the customer will pay is to study each industry and its products, then ask some customers — *both shippers and receivers* — in each industry such questions as :

why they use railroad service to the degree they do;

why the share assigned to railroads is not larger;

whether traffic not now moving by rail could be attracted to rail movement under any circumstances;

what concessions would be necessary to attract how much traffic;

how long we'd have to wait for it; and

what railroad practices would have to be altered.

Then evaluate the replies, frame some new questions and go back again. Shippers will help you if they are convinced you want to help them.

There is no magic formula here. It is pragmatism — finding out what will work and doing it — that's all. It costs money to do all this fact-finding. It's time consuming. According to some shippers it's 20 or 30 years too late. But the superior economy of the fully loaded freight car for most of the nation's tonnage (even in the shorter distances, if it's loaded heavily enough) is unshaken. Rate-making which uses this superior economy wisely and selectively can scarcely fail to hold and increase the railroads' traffic and earnings.

Seven opportunities for more profits.

Commodity « A ».

Railroads' present share. — Less than one-fifth of total. Rail tonnage declining despite commodity growth trend of 1 % per year.

Pricing system. — Usually method 2. *Charges equalized,* but in important markets near producing points there are some instances also of method 1 — *delivered pricing.*

Marketing situation. — Extremely competitive. Many producers, thousands of receivers. Commodity is almost a style item, often requiring frequent, small shipments. Inventory control is a problem. Warehousing is increasing as competitive tool to provide service to customers. Some receivers have credit problems, think twice before expanding inventories. Some receivers off-rail, tendency to locate off-rail. Rails have no traffic at all under delivered pricing.

Conclusions. — Rails have already lost nearly all the manufacturer-receiver traffic, though they still have most of the intra-company traffic. There is very little problem of dilution of present rail revenue by rate changes because there isn't any, practically. Where full freight allowed applies, rate action must be liberal to be effective.

Indicated railroad action. — *a*) set rates as low as rail costs will permit at short hauls at low minima. Publish continuous incentives at substantial discount to induce maintenance of high inventories and encourage warehousing by manufacturers. Multiple car rates to encourage warehousing would help; *b*) lowest possible rates to selected, delivered price markets where the rails now have no traffic at all.

Commodity « B ».

Railroads' present share. — Approximately two-fifths still on rails. Substantial annual decrease in rail tonnage. Commodity's growth trend — up 4.5 % per year.

Pricing system. — Method 3. — *Full freight charges allowed, by cheapest available transportation.*

Marketing situation. — Quite competitive. A few producers and relatively few receivers. Most receivers have plenty of space, good credit, good volume. Minimum weights not a problem. Production centralized geographically. An important minority of these receivers are off-rail. Rail has a substantial share of the long-haul tonnage.

Conclusions. — There is a continuing erosion of traffic in the shorter hauls. Longer-haul traffic is relatively safe under present rate structure. The major rail disability is the unloading cost and sometimes the drayage cost. Receivers will put up with slow service to save some money.

Indicated railroad action. — *a*) Set short-haul rates somewhat below truck cost (where rail costs permit) at competitively low minima to get on-rail traffic. Substantial flat (cents per lb.) discount over next few thousand pounds to counter truck competition, overcome loading and drayage disabilities, establish real incentive for industry to use rail. *Less* of a discount over remaining car capacity, aimed solely to encourage high loading. Multiple car rates at limited discounts; *b*) On long-haul traffic — apply only the smaller discount aimed at achieving higher loading.

Commodity « C ».

Railroads' present share. — About half of traffic on rails. Rail tonnage declining. Commodity's growth trend — up 2.6 % per year.

Pricing systems. — Usually method 2. — *Charges equalized,* but in important markets near producing points method 1, *delivered pricing,* is in practice with zones spreading.

Marketing situation. — A limited number of manufacturers, many receivers. Shippers favor use of rail for marketing policy reasons. Fairly standard product, high turnover. High minima not a great problem. Rail has a loading-unloading disadvantage with one older type of equipment, not with another and newer type.

Conclusions. — Outside the delivered price markets, a small difference in rate is enough to hold the traffic on the rails. In some of the larger cities the diversion to truck is complete and rate action would have to be drastic to be effective. Rates should promote the use of older, non-specialized equipment. Low long-haul rates might break down the freight equalization system and destroy the rail share.

Indicated railroad action. — *a*) Set rates slightly below truck cost, where rail costs permit, particularly at short hauls, at low minima. Provide continuing incentive above that, enough to encourage heavy loadings, overcome some unloading disabilities. This should result in fairly generous margins on most hauls — much higher than in instance « A »; *b*) Take aggressive action with low rates, at high minima to the delivered price markets where rails now have nothing; *c*) Maintain relatively remunerative rates where new equipment is supplied.

Commodity « D ».

Railroad's present share. — Two-fifths now on rails. Substantial annual decrease in railroad tonnage despite commodity's growth trend — up 14 % per year.

Pricing system. — Complicated pricing. Sometimes method 3. — Shipper routes freight; sometimes method 4; sometimes method 5.

Marketing situation. — A few large companies, many receivers of different types. Three special points apply here : *a*) rail has an actual service advantage here in some cases; *b*) there is a trend to decentralization of production which threatens some of the present rail traffic and *c*) some receivers would much prefer to receive in split carloads and split truckloads, and do receive that way.

Conclusions. — Rail's present traffic is vulnerable on both long and short hauls. It is doubtful if the shipments on which rails have an advantage can be separated from that where they are at a disadvantage. A vigorous rate policy is indicated.

Indicated railroad action. — Lower rates on short hauls which are very vulnerable. Avoid too-high rates on the longer hauls to discourage decentralization. Review split carload rates and charges to see if they are compensatory on this traffic.

Commodity « E ».

Railroads' present share. — Approximately half on rails. Substantial annual decrease in railroad tonnage. Commodity's growth trend — up 0.5 % per year.

Pricing system. — Method 2.

Marketing situation. — A relatively few shippers, a fair number of receivers. Many products are specialties which are hard to duplicate elsewhere. Receiver controls routing. Inventory maintenance somewhat expensive.

Conclusions. — Rail loss of traffic is continuing and severe. Rail disabilities are : 1) inventory maintenance costs, increased by slow and undependable service; and 2) unloading disabilities; and 3) the sheer convenience of truck service. Long-haul traffic is not in jeopardy.

Indicated railroad action. — Low rates on short hauls, continuing incentives for higher loading designed to overcome inventory costs, unloading disabilities. Provide adequately higher margins for longer hauls.

Commodity « F ».

Railroads' present share. — Only a small percentage of total tonnage still on the railroads.

Pricing system. — Method 1.

Marketing situation. — A limited number of large manufacturers, many receivers. A few very favorably located manufacturers who favor truck. It doesn't cost them much to provide this service.

Conclusions. — The favorably situated manufacturers established delivered pricing, which knocked the rails out of the picture. Other manufacturers would be receptive to low volume rates, to get their competitive position back.

Indicated railroad action. — Moderate rates at low minimum weights to encourage rail traffic to wholesalers and others and perhaps invite a revision of the whole price structure to absorption of rail freight charges only. Lower rates at or near car capacity to encourage warehousing by manufacturers, direct carload buying by business consumer.

Commodity « G ».

Railroads' present share. — Less than one-third on rail. Average annual *increase* in rail originations substantial. Commodity's growth trend — up 16 % per year. Note : Rail participation began in the last 5 years, helped by a very successful rate adjustment which attracted much of the warehouse traffic. The railroads' share is now slipping.

Pricing system. — Methods 1, 5 and 6 concurrently. Quantity discount prices are often quoted but prices are on a delivered basis.

Marketing situation. — A limited number of large manufacturers, many small producers, an extremely large number of receivers of all sizes, most of whom are off-rail, are treated deferentially by producers' sales forces due to the high profit and high growth rate of the commodity. In one sector rail has an advantage due to special equipment, high capacity Warehousing is increasing in importance. Sometimes rail is used, plant to warehouse, sometimes not.

Conclusions. — Rates are not the most important answer on this commodity. Major factors in the rails' poor competitive showing are : 1) damage; 2) undependable service; 3) the absence of knowledge by the receivers of the possible advantages of rail service in their operations and 4) some lack of knowledge by the shippers of successful packaging techniques.

Indicated railroad action. — *a*) Low-profit rates at low minima, continuous incentives. *b*) Different rate treatment should apply for different equipment. Short haul rates could show substantial margins in some cases. *c*) A sales campaign to teach safe packaging to the shipper, promote equalization of freight charges and convert shippers and receivers to bulk handling.

NEW BOOKS AND PUBLICATIONS.

[**385** (08(489)]

DANSKE STATSBANER — 1960 *(The Danish State Railways — 1960)*. A pamphlet (8 1/4 × 11 1/2 in.) of 25 pages, copiously illustrated. — 1961. Published by the General Management of the Danish State Railways, Copenhagen.

The Danish State Railways (D.S.B.) have just published for the first time as an illustrated pamphlet intended to be widely circulated, their report on the year 1960. The sketches, drawings, photographs and diagrams remove any suspicion of dullness from this brief (24 pages) but instructive pamphlet.

For the first time for many years, the 1960 balance sheet closed with a slight surplus (about 700 000 crowns). The railway system of some 2 800 km transported about 4.5 milliard traffic units (a figure slightly below that for the previous year) with a staff of 27 800 employees (a reduction of 280). The number of stations was reduced from 524 to 517.

Financial equilibrium was obtained on the one hand by increasing the tariffs as from the 1st July 1959 (by between 5 and 20 %), and on the other hand, thanks to still more extensive dieselisation of the traction (the 76 Diesel locomotives hauled 4.5 millions of gross t/km, compared with 1.5 millions for the 308 steam locomotives). New Diesel locomotives are also on order.

Half the receipts (280 millions) came from the passenger traffic. Yet some 5 000 wagons were loaded every day. The stock consists of some 1 500 coaches and rail motorcoaches, and nearly 14 000 wagons of all kinds.

The Danish State Railways are one of the largest shipowners in the country. They have 28 ferry-boats and ships, 2 of which were put into service during 1960. Some of these are special types for carrying motorcars; the total traffic under this heading amounted to 35 000 vehicles.

The D.S.B. continue to improve their equipment (track, signals, rolling stock, ferry-boats, harbour installations, electronic equipment, etc.) as well as continuing, in collaboration with the D.B. to build the through line « as the crow flies », which will be opened to traffic in the summer of 1963.

P. Sch.

[**656** .212 .5 (43)]

RANGIERTECHNIK *(Marshalling technique)* Number 20. Special issue no. 12 of the « *Eisenbahntechnische Rundschau* », September 1960. — Prepared by the Special Commission for Marshalling Technique of the Deutsche Bundesbahn. — Pamphlet (7 7/8 × 11 3/4 in.) of 70 pages with illustrations. — 1960 Darmstadt, Carl Rhörig Verlag OHG Holzhofallee 33*a* (Price : Dm 14.—; for subscribers to **ETR** : DM 11.20.).

Number 20 of « Rangiertechnik », which appeared in September 1960, commemorates the 10th anniversary of the setting up of the Technical Commission for studying marshalling yards. At the same time it sums up, as is done every year, the knowledge acquired in this field by the Deutsche Bundesbahn, after a preface from Dr. GEITMANN, Chairman of the D.B., in reports written by Messrs Dr.-Eng. Recker, Dipl. Eng. Delvendahl, Unbehagen, Professor Klein, Dr.-Eng. Born, Dr.-Eng. Delpy, Dipl.-Eng. Sieverling and Professor Massute.

The general report on the work of the

decade calls to mind the fact that during these ten years some hundred different questions have been examined. The best general layout sites the reception sets quite close to the marshalling sets, and a single height of hump (both summer and winter). Unless the making up of the trains involves a great deal of shunting, it is advantageous to do away with the departure set, provided this does not jam up the marshalling sidings. Accurate weighing of the moving wagons is still being studied. Very accurate processes already make it possible to measure the resistance to running of the wagons. Lubrication of rails on curves has been found to be advantageous. Nomographs make it possible to determine the rolling distances.

Progress in signalling and telecommunications have extended the size of the zones served and make it possible to have only two control posts. As regards lighting, it has been found that large pylons are much less satisfactory than a well distributed system of lighting.

Detailed studies of automation of track brakes to the fullest possible extent have been carried out. The obtaining of a very short time of reaction has led to the development of the « Wuppertal » type brake. A final braking with low residual speed has so far been unrealisable without using linesmen. This fact has led to the development of a series of small track brakes.

Important points, the study of which is being begun and intensified, are the reduction of the clerical work by greater mechanisation and the simplification of the work of the checkers, accurate control of the push up locomotive from a distance, and the best characteristics for wagons.

A new subject of study for the Commission has arisen with the carriage depots and their installations. An article by Professor Massute is devoted to this point.

Detailed reports of each of the studies made during the year 1959-60 are given. A thorough and systematic study of the construction and working of a departure set of sidings is given. A detailed analysis is given for a particular case (Mannheim marshalling yard) of a double juxtaposed marshalling yard (one for each direction of running), which shows the importance of making the dimensions of each installation suitable for the traffic with which it will have to deal.

The special number studies in detail « Wuppertal » type track brakes, which can also be used on lines on a curve. A long and detailed study shows how these brakes can be controlled electronically and gives detailed working diagrams of the necessary parts. The special number also gives a complete description of the Duisburg-Wedgu marshalling yard which is equipped with the various instruments and shows the advantage to be obtained from the use thereof.

P. Sch.

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(SEPTEMBER 1961)

[016 .385 (02]

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In French.

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L’ensemble électronique de gestion de la S.N.C.F.
Extrait de *L’Année Ferroviaire 1961*, édité par Plon, rue Garancière, Paris (6^{e}). Une brochure (13 × 21 cm) e 32 pages, avec schémas.

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Zürich, Verlag Leemann. Un volume (18 × 25 cm) de VI + 928 pages, avec 391 figures. (Prix : relié, 70 fr. uis.)

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Traité de chauffage et de ventilation. 14^{e} édition. Traduit par W. RAIRS.
Paris (6^{e}), Béranger, éditeur, 15, rue des Saints-Pères. n volume relié (18 × 27 cm) de 780 pages, avec 547 gures, 43 tableaux, 2 abaques et 15 planches hors texte. rix : 135 NF.)

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tion, 30, Church Street, N.Y. 7. (Price : $ 5.)

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[**016** .385 (05]

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In French.

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1961 **721** .1
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GANSEFORTH (J.). — **Steigerung der Streckenleistung durch Selbstblock** im Schienenverkehr. (750 Wörter & Abb.)

1961 **656** .257
Siemens-Zeitschrift, Juli, S. 556.
HRDY (K.). — **Deutsch-französischer Grenzbahnhof erhielt ein gemeinsames Stellwerk.** (600 Wörter & Abb.)

Signal und Draht. (Frankfurt am Main.)

1961 **656** .259
Signal und Draht, Juni, S. 81.
LENTZ (G.). — **Achszählanlagen.** (4 500 Wörter & Abb.)

1961 **656** .254
Signal und Draht, Juni, S. 89.
OTTER (W.). — **Eine Fernsehanlage zur Zugschlussbeobachtung.** (800 Wörter & Abb.)

In English.

AEI Engineering. (London.)

1961 **656** .212 .5 (42
AEI Engineering, No. 6, June, p. 228.
FOULKES (R.M.). — **Automatic control equipment a Margam marshalling yard.** (4 000 words & figs.)

Electric Traction on the Railways. (Brussels.

1961 **621** .33
Bulletin of the International Railway Congress Asso ciation — Electric Traction on the Railways, No. 5 May, p. 205.
BOBBERT (H.). — The maintenance of **accumulato rail motor coaches** in the repair shops. Evolution an progress. (4 500 words & figs.)

1961 **621** .431 .7
Bulletin of the International Railway Congress Asso ciation — Electric Traction on the Railways, No. 5 May, p. 217.
ATTOCK (M.O.) and FLETCHER (S.). — Som ideas on the maintenance of **diesel-electric locomotive** (8 600 words & figs.)

1961 **621** .2
Bulletin of the International Railway Congress Asso ciation — Electric Traction on the Railways, No. May, p. 239.
WAGNER (R.). — **Electrification** in the Saar. (3 20 words & figs.)

1961 **621** .431 .72 (4
Bulletin of the International Railway Congress Asso ciation — Electric Traction on the Railways, No. May, p. 249.
Russian 3 000 HP **Diesel-electric locomotive.** (1 1 words & figs.)

1961 **621** .33 (54)
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 5, May, p. 254.
Electrification of the Indian Railways with 25 kV, 50 cycles. Inauguration of the Asansol-Dhanbad Secion. (360 words, 1 chart.)

The Engineer. (London.)

1961 **656** .28 (42)
The Engineer, June 23, p. 1037.
Electric train accidents and failures. (1 000 words.)

1961 **625** .282 (42)
The Engineer, June 23, p. 1040.
Diesel mixed traffic locomotives. (300 words & fig.)

1961 **625** .143 .5 (42)
The Engineer, June 30, p. 1077.
Fastening for flat-bottomed rails. (200 words & fig.)

1961 **625** .253 (42)
The Engineer, June 30, p. 1078.
Disc brakes for railway freight vehicles. (1 000 words & figs.)

Journal of the Institution of Electrical Engineers. (London.)

1961 **656** .2 (42)
Journal of the Institution of Electrical Engineers, June, p. 364.
Railway modernization conference. (1 800 words & figs.)

1961 **621** .336
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Behaviour of electric-railway-traction overhead equipment. (600 words & figs.)

Journal, The Institution of Locomotive Engineers, (London.)

1960-61 **625** .244
Journal, The Institution of Locomotive Engineers, No. 277, Vol. 50 (Part No. 5), p. 532.
EAMES (T.A.). — **Refrigerated transport on railways.** (11 000 words & figs.)

1960-61 **621** .131 .3
Journal, The Institution of Locomotive Engineers, No. 277, Vol. 50 (Part No. 5), p. 564.
MALCOLM (A.C.D.). — **The final inspection and testing of locomotives for Oversea Railways.** (14 000 words & figs.)

Journal of the Institute of Transport. (London.)

1961 **656** .2
Journal of the Institute of Transport, May, p. 105.
HAWKINS (L.C.). — **Mass transportation in the future.** (4 000 words.)

International Railway Journal. (The Hague.)

1961 **621** .431 .72 (43)
International Railway Journal, May, p. 35.
East Germany's new Diesel-hydraulic. (400 words & figs.)

1961 **625** .251
International Railway Journal, May, p. 48.
Brake applications limit wheel slip. (2 400 words & figs.)

Modern Transport. (London.)

1961 **656** .2 (42)
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HARRISON (J.F.). — **Impact on B.R. modernisation plan.** (4 200 words & tables.)

1961 **656** .2 (42)
Modern Transport, May 27, p. 3; June 3, p. 5.
Railway re-organisation I-II. (4 500 words.)

1961 **621** .431 .72 (42)
Modern Transport, May 27, p. 13.
New Diesel-hydraulic locomotive. (1 900 words & figs.)

1961 **656** .25 (42)
Modern Transport, June 3, p. 13.
Kent Coast electrification (*to be continued*). (1 200 words & figs.)

1961 **621** .338 (42)
Modern Transport, June 10, p. 3.
Metropolitan line re-equipment. Dual-purpose rolling stock. (*to be continued.*) (1 200 words & figs.)

1961 **656** .212 .5 (42)
Modern Transport, June 10, p. 10.
KUBALE (J.C.). — **Automatic marshalling yards.** (*Cont.*) (1 400 words.)

Journal, The Permanent Way Institution (Tonbridge.)

1961 **656** .25
Journal, The Permanent Way Institution, Part I, Vol. 79, p. 35.
CUNLIFFE (J.P.). — **Modern railway signalling.** (1 800 words & figs.)

1961 **385** .524
Journal, The Permanent Way Institution, Part I, Vol. 79, p. 53.
CAMERON (J.C.F.). — **Productivity, morale and incentive bonus schemes.** (2 200 words.)

Railway Age. (New York.)

1961 **625** .244 (73)
Railway Age, March 27, p. 41.
PFE builds new-type reefer. (600 words & fig.)

1961 **656** .212 (73)
Railway Age, April 3, p. 16.
Santa Fe's newest rail-truck terminal opens at Kansas City. (300 words & figs.)

1961 **625** .242 (73)
Railway Age, April 17, p. 16.
New stainless alloy gets test in 90-ton car. (600 words & figs.)

1961 **625** .235 (73)
Railway Age, May 22, p. 12.
New D and H paint facilities will process 1 500 cars per year. (600 words & figs.)

1961 **656** .225 (492)
Railway Age, May 22, p. 22.
BEADLE (D.W.). — **Holland looks at piggyback.** (2 200 words & figs.)

The Railway Gazette. (London.)

1961 **625** .172 (42)
The Railway Gazette, May 19, p. 561.
New dynamometer car for British Railways. (1 400 words & figs.)

1961 **621** .131 .3 (42)
The Railway Gazette, May 19, 564.
Controlled road testing system. (800 words & figs.)

1961 **656** .215 (42)
The Railway Gazette, May 19, p. 566.
SAUNDERS (H.). — **Lighting in marshalling yards.** (1 000 words & figs.)

1961 **656** .25 (42)
The Railway Gazette, May 26, p. 590.
Re-signalling at Barking, Eastern Region, British Railways. (1 500 words & figs.)

1961 **621** .33 (42)
The Railway Gazette, June 2, p. 627.
Kent Coast electrification. Phase 2 progress. (600 words & figs.)

1961 **621** .33 (44)
The Railway Gazette, June 2, p. 629.
Railway electrification in Eastern France. (900 words & figs.)

1961 **625** .172 (42)
The Railway Gazette, June 16, p. 677.
Modernisation of permanent way on the Eastern Region. (2 000 words & figs.)

1961 **656** .25 (54)
The Railway Gazette, June 16, p. 682.
Tokenless block working on single-line sections. (900 words & figs.)

1961 **656** .284 (42)
The Railway Gazette, June 16, p. 690.
Ministry of Transport accident report : Electrical fire between Redbridge and Gants Hill, Central Line, London Transport Railways, on August 11, 1960. (1 900 words.)

1961 **625** .28
The Railway Gazette, June 23, p. 708.
High-performance lightweight trains Diesel and electric. (2 200 words & figs.)

1961 **656** .28 (42)
The Railway Gazette, June 23, p. 716.
Ministry of Transport accident report. (1 800 words & table.)

1961 **625** .242 (54)
The Railway Gazette, June 30, p. 733.
BHATTACHARYA (A.C.). — **Heavy capacity bogie open wagon for Indian Railways.** (400 words & figs.)

1961 **656** .253 (42)
The Railway Gazette, June 30, p. 734.
Automatic two-stage disc brake for British Railways. (500 words & figs.)

Diesel Railway Traction. (London.)

1961 **621** .431 .72 (42)
Diesel Railway Traction, May, p. 177.
A Diesel-Electric locomotive and its tests. (3 000 words & figs.)

1961 **621** .431 .72 (45
Diesel Railway Traction, May, p. 185.
Italian bogie locomotive. (2 000 words & figs.)

1961 **621** .431 .72
Diesel Railway Traction, May, p. 198.
Locomotive with differential transmission. (1 300 word & figs.)

1961 **621** .431 .72 (6
Diesel Railway Traction, May, p. 205.
Line-service locomotives for Nigeria. (2 000 word & figs.)

Railway Locomotives and Cars. (New York.)

1961 **625** .214 (73)
Railway Locomotives and Cars, June, p. 24.
Uniform roller bearing inspections. (1 000 words & figs.)

1961 **625** .245 (73)
Railway Locomotives and Cars, June, p. 33.
Center flow car built of aluminum. (800 words & figs.)

1961 **625** .245 .(73)
Railway Locomotives and Cars, June, p. 38.
NYC introduces flexi. van Mark III. (300 words & figs.)

1961 **621** .131 .1
Railway Locomotives and Cars, June, p. 50.
Could sparking improve adhesion. (900 words & figs.)

Railway Magazine. (London.)

1961 **625** .13 (42)
Railway Magazine, June, p. 380.
PRIOR (F.J.J.). — **Examination of tunnels.** (1 200 words & figs.)

Quarterly Report. Railway Technical Research Institute, J.N.R. (Tokyo.)

1960 **656** .22 (52)
Quarterly Report. Railway Technical Research Institute, J.N.R., Vol. 1. No. 3, p. 1.
SHIO TANI (M.), MAKINO (K.), NISHIZAWA (S.), HAYASHIDA (C.) and OGUSHI (J.). — **A field experiment** on the « train draft ». (1 800 words, tables & figs.)

1960 **621** .33 (52)
Quarterly Report, Railway Technical Research Institute, J.N.R., Vol. 1. No. 3, p. 9.
AMAMIYA (Y.). — **A research on radio noises in medium and high frequency regions generated by electric cars.** (4 000 words, tables & figs.)

1960 **621** .335 (52)
Quarterly Report. Railway Technical Research Institute, J.N.R., Vol. 1. No. 3, p. 26.
NOMURA (Y.) and others. — **Performance test of the new electric-car train « KODAMA ».** (3 000 words & figs.)

1960 **621** .336 (52)
Quarterly Report. Railway Technical Research Institute, J.N.R., Vol. 1. No. 3, p. 34.
IWASE (M.). — **Current collection by the pantograph and its wear.** (1 200 words & figs.)

Railway Signaling and Communications. (New York.)

1961 **656** .25 (73)
Railway Signaling and Communications; May, p. 15.
Special report. Railroad microwave. (3 600 words & figs.)

1961 **656** .25 (73)
Railway Signaling and Communications; May, p. 22.
Railroad will pay for CTC out of accrued savings. (300 words & figs.)

1961 **625** .214 (73)
Railway Signaling and Communications; June, p. 19.
Trainmen read hotbox locator. (1 000 words & figs.)

Railway Steel Topics. (Sheffield.)

1961 **625** .143 (0
Railway Steel Topics, Spring, p. 28.
BABB (A.S.) and BRINSMEAD (K.). — **The design testing and selection of rail sections.** (4 500 words & figs.)

1961 **624** (0
Railway Steel Topics, Spring, p. 45.
BABB (A.S.). — **Tests to destruction of two pre-tensioned concrete railway bridge beams.** (2 300 words & figs.)

Railway Track and Structures. (Chicago.)

1961 **625** .172 (73)
Railway Track and Structures, May, p. 35.
Tests machine for resetting rail anchors. (1 400 words & figs.)

Trains Illustrated. (London.)

1961 **656** .2 (73)
Trains Illustrated, June, p. 356; July, p. 419.
TODD (J.G.). — **Impressions of railroading.** (5 400 words & figs.)

In Spanish.

Boletin de la Comisión Permanente de la Asociación del Congreso Panamericano de Ferrocarriles. (Buenos Aires.)

1961 **656** .2 (82)
Boletin de la Com. Perm. de la Asociación del Congreso Panamericano de Ferrocarriles, enero-febrero, p. 17.
CASTELLO (M.F.). — **Situacion de los Ferrocarriles del Estado Argentino.** (10 000 palabras.)

1961 **656** .222 .5 (460)
Boletin de la Com. Perm. de la Asociación del Congreso Panamericano de Ferrocarriles, enero-febrero, p. 75.
El tren TALGO. Datos estadísticos y números índices. (800 palabras y cuadros.)

1961 **656** .2 (82)
Boletin de la Com. Perm. de la Asociación del Congreso Panamericano de Ferrocarriles, marzo-abril, p. 44.
Ferrocarriles del Estado Argentino. — Participación del personal ferroviario en la solución de los problemas técnicos y económicos. (800 palabras.)

1961 **385** (06 .1 (7+8)
Boletin de la Com. Perm. de la Asociación del Congreso Panamericano de Ferrocarriles, marzo-abril, p. 49.
X Congreso Panamericano de Ferrocarriles — Conclusiones. (1 000 palabras.)

Ferrocarriles y Tranvias. (Madrid.)

1961 **656** (82)
Ferrocarriles y Tranvias, Vol. 27-I, nº 305, p. 2; vol. 27-II, nº 306, p. 36.
LOPEZ ABUIN (A.J.). — **Hay crisis del transporte en la Argentina ?** (*Continuará.*) (7 100 palabras.)

1961 **347** .762
Ferrocarriles y Tranvias, vol. 27-I, nº 305, p. 8.
SANCHEZ GAMBORINO (F.-M.). — **El derecho de los eventuales usuarios a la prestación de los servicios de transportes.** V. (*Continuará.*) (2 500 palabras.)

1961 **621** .33 (42)
Ferrocarriles y Tranvias, vol. 27-I, nº 305, p. 12.
COCK (Ch.). — **La Conferencia británica sobre electrificación.** (900 palabras.)

1961 **625** .42 (460)
Ferrocarriles y Tranvias, vol. 27-I, nº 305, p. 14.
Notas y datos estadísticos sobre **construcción y explotación del Metropolitano de Madrid.** (3 000 palabras y cuadros.)

1961 **656** .225 (73)
Ferrocarriles y Tranvias, vol. 27-II, nº 306, p. 44.
DE LA FUENTE (J.). — **Coordinación ferrocarril-carretera.** Un paso mas : el « piggy-back ». (1 500 palabras y cuadros.)

1961 **656** .2
Ferrocarriles y Tranvias, vol. 27-II, nº 306, p. 50.
DE INCHAURRAGA (P.). — **Explotación del ferrocarril.** (700 palabras.)

In Italian.

Alluminio. (Milano.)

1961 **621** .31
Alluminio, maggio, p. 255.
Sostegno di lega leggera per linee elettriche ad altissima tensione. (300 parole & fig.)

1961 **656** .225
Alluminio, maggio, p. 257.
Passerelle di carico di lega di alluminio. (600 parole & fig.)

1961 **656** .225
Alluminio, giugno, p. 323.
Contenitori « Tote System » di lega leggera per prodotti in polvere. (500 parole & fig.)

Giornale del Genio Civile. (Roma.)

1961 **625** .13
Giornale del Genio Civile, maggio, p. 392.
GOFFI (L.). — Il problema della **misura degli sforzi indotti nei rivestimenti delle gallerie** dalla spinta della montagna. (3 000 parole & fig.)

Ingegneria Ferroviaria. (Roma.)

1961 **385** .11
Ingegneria Ferroviaria, maggio, p. 387.
STAGNI (E.). — **Un problema classico di ricerca operativa : la migliore utilizzazione di un finanziamento di data entità.** (2 500 parole, tabella & fig.)

1961 **656** .25 (45)
Ingegneria Ferroviaria, maggio, p. 393.
TENTI (E.). — **L'ammodernamento delle regolamentazione di sicurezza** sulle Ferrovie dello Stato. (10 000 parole.)

1961 **625** .42 (45)
Ingegneria Ferroviaria, maggio, p. 407.
PIZZORNO (A.). — La congestione del traffico di superficie nelle grandi città e la **metropolitana di Milano.** (3 500 parole & fig.)

1961 **625** .1 (45)
Ingegneria Ferroviaria, maggio, p. 415.
PELLIS (P.). — **I lavori per l'unificazione delle stazioni di Poggioreale** verso la Jugoslavia. (3 500 parole & fig.)

1961 **656** .2 (94)
Ingegneria Ferroviaria, maggio, p. 424.
VASSALLO (G.). — **Il sistema ferroviario australiano.** (4 000 parole, tabelle & fig.)

1961 **656**
Ingegneria Ferroviaria, maggio, p. 433; giugno, p. 535.
SANTORO (F.). — **La partecipazione delle ferrovie al traffico stradale.** (6 500 parole.)

1961 **656** .285 (45)
Ingegneria Ferroviaria, maggio, p. 439.
AMERIO (A.). — Gli **incidenti di esercizio** sulle ferrovie italiane. (3 500 parole & tabelle.)

Politica dei Trasporti. (Roma.)

1961 **621** .33 (44) & **621** .431 .72 (44)
Politica dei Trasporti, aprile, p. 190.
Elettrificazione e trazione Diesel nelle ferrovie francese. (1 000 parole.)

Rivista di Ingegneria. (Milano.)

1961 **621** .436
Rivista di Ingegneria, maggio, p. 501.
LENTI (F.). — **L'uso di oli combustibili nei motori a ciclo Diesel.** (2 000 parole.)

1961 **624**
Rivista di Ingegneria, maggio, p. 505.
MATTIAZZO (F.). — **Calcolo delle strutture composte da lastre-piastre a contorno rettangolare fra loro connesse** (in assenza di travi). (*Continua.*) (3 000 parole, tavole & fig.)

In Netherlands.

De Ingenieur. (Den Haag.)

1961 **656** .211 .5 (43)
De Ingenieur, nr 23, 9 juni, p. B. 101.
De nieuwe perronoverkapping van het Centraal Station te München. (900 woorden & fig.)

1961 **654**
De Ingenieur, nr 24, 16 juni, p. E. 35.
Multitooncodesignaleringssysteem. III. **De opbouw van het systeem,** door E. RIJSDORP. (4 000 woorden & fig.). — IV. **De uitvoering van het systeem,** door A.G.C. VAN BRUGGEN. (2 500 woorden & fig.)

1961 **691**
De Ingenieur, nr 25, 23 juni, p. Bt. 77.
SMEELE (J.J.). — **Gas- en schuimbeton.** (2 000 woorden & fig.)

1961 **621** .8
De Ingenieur, nr 26, 30 juni, p. W. 99.
SCHLÖSSER (W.M.J.) en OLDERAAN (W.F.T.). — **Een analogon-theorie van de aandrijvingen van de roterende beweging.** (3 000 woorden & fig.)

Spoor- en Tramwegen. (Den Haag.)

1961 **656** .222 .5 (44)
Spoor- en Tramwegen, nr 12, 15 juni, p. 193 en nr 13, 29 juni, p. 218.
VAN DEN DOL (W.H.). — **Le Mistral.** (*Wordt vervolgd.*) (4 000 woorden & fig.)

1961 **625** .2
Spoor- en Tramwegen, nr 12, 15 juni, p. 200.
KARSKENS (J.J.). — Iets over **twee- en drieassig materieel.** (2 500 woorden & fig.)

1961 **621** .33
Spoor- en Tramwegen, nr 12, 15 juni, p. 204.
STUNNENBERG (J.). — Opmars van de **elektrische tractie.** (600 woorden & tabelen.)

1961 **385** .113 (492)
Spoor- en Tramwegen, nr 13, 29 juin, p. 212.
Het jaarverslag 1960 van de Nederlandsche Spoorwegen. (3 000 woorden.)

1961 **625** .172
Spoor- en Tramwegen, nr 13, 29 juni, p. 216.
HAUER (J.M.). — Samenwerking op het gebied van de **mechanisatie van het wegonderhoud.** (1 000 woorden & fig.)

1961 **656** .254 (57)
Spoor- en Tramwegen, nr 13, 29 juni, p. 222.
LESJKOW (A.). — **Televisie op de Transsiberische Spoorweg.** (400 woorden.)

In Portuguese.

Gazeta dos Caminhos de Ferro. (Lisboa.)

1961 **625** .232
Gazeta dos Caminhos de Ferro, nº 1765, 1 Julho, p. 139.
de BRITO LEAL (C.). — **Um natal no vagâo-restaurante.** (1 200 palavras.)

In Russian (= 491 .7).

Avtomatica, Telemekhanika i Svias. (Moscou.)

1960 **656** .256 .3 = 491 .7
Avtomatica, Telemekhanika i Svias, janvier, p. 4.
SAMYATINE (W.A.). — **Lignes d'alimentation à deux circuits des dispositifs du block automatique et des équipements en ligne.** (1 800 mots, tableaux & fig.)

1960 **656** .254 = 491 .7
Avtomatica, Telemekhanika i Svias, janvier, p. 8.
GYÉRASSIÉNKOV (V.I.) et KRIWITZKI (K.A.). — **Nouvel aménagement électronique de la commande centralisée.** (3 100 mots & fig.)

1960 **62** (01 = 491 .7
Avtomatica, Telemekhanika i Svias, janvier, p. 18.
TANTZYOURA (A.A.). — **Particularités des oscillations avec modulation polaire et modulation de phase.** (2 200 mots & fig.)

1960 **656** .256 = 491 .7

Avtomatica, Telemekhanika i Svias, février, p. 6.

FYÉDOTYÉV (P.W.) et NARKÉVITCH (A.K.). — **Schémas des installations du block semi-automatique** avec circuits de ligne polaire et leur coordination avec les dispositifs d'itinéraire et de contrôle. (2 100 mots & fig.)

1960 **654** = 491 .7

Avtomatica, Telemekhanika i Svias, février, p. 11.

VOLOTZKOI (A.N.) et DIVNOGORTZEV (T.P.). — **Téléphonie synthétique.** (1 900 mots & fig.)

1960 **656** .259 = 491 .7

Avtomatica, Telemekhanika i Svias, février, p. 16.

BRULÉYÉV (A.M.) et KHUAN SYOU-KOUGNE. — **Circuits de voie** alimentés par courants de signaux à fréquence élevée. (2 200 mots, tableaux & fig.)

1960 **656** .254 = 491 .7

Avtomatica, Telemekhanika i Svias, mars, p. 1.

BUCHBINDER (L.I.). — **Nouvelle installation de télécommunications de conférence simultanée.** (1 800 mots & fig.)

1960 **656** .257 = 491 .7

Avtomatica, Telemekhanika i Svias, mars, p. 6.

MASLOV (A.P.). — **Schéma perfectionné de block de gare,** système Natalyévitch. (1 100 mots & fig.)

1960 **654** = 491 .7

Avtomatica, Telemekhanika i Svias, mars, p. 10.

WOLKOV (V.M.). — L'organisation des **télécommunications téléphoniques** omnibus en utilisant des câbles hertziens. (1 500 mots & fig.)

1960 **656** .254 = 491 .7

Avtomatica, Telemekhanika i Svias, avril, p. 6.

BOUTZ (W.D.). — **Mécanisation des travaux de réparation et d'entretien courant** des lignes des télécommunications et de sécurité. (1 400 mots & fig.)

1960 **656** .254 = 491 .7

Avtomatica, Telemekhanika i Svias, avril, p. 9.

GUÉLTZEL (M.Y.). — **Canaux de télécommande à bandes étroites de haute fréquence.** (2 000 mots & fig.)

1960 **656** .256 .3 = 491 .7

Avtomatica, Telemekhanika i Svias, mai, p. 4.

LÉONOV (A.A.). — Augmentation des propriétés protectrices du **block automatique à signaux lumineux à projecteurs.** (2 100 mots & fig.)

1960 **621** .315 = 491 .7

Avtomatica, Telemekhanika i Svias, mai, p. 8.

YÉRCHOV (I.M.) et YÉVSYÉYÉV (I.T.). — **Protection des câbles contre la corrosion,** provoquée par les courants dérivés à la terre du circuit traction. (1 900 mots & fig.)

1960 **656** .259 = 491 .7

Avtomatica, Telemekhanika i Svias, juin, p. 4.

BRULÉYÉV (A.M.), CHICHLYAKOV (A.V.) et MOJAYÉV (S.S.). — Système perfectionné de **répétition des signaux dans les cabines de conduite.** (1 900 mots & fig.)

1960 **654** = 491 .7

Avtomatica, Telemekhanika i Svias, juin, p. 8.

KORLASS (I.I.) et IVANOV (R.I.). — **Aménagement de la radio par câbles hertziens,** type PM-24. (2 000 mots & fig.)

1960 **656** .25 = 491 .7

Avtomatica, Telemekhanika i Svias, juin, p. 16.

STUHLMANN (M.A.). — **Reconstruction des installations de sécurité et de signalisation.** (2 500 mots & fig.)

Eléktritchéskaïa i Tyéplovosnaïa Tyaga. (Moscou.)

1960 **385** .581 (47) = 491 .7

Eléktritchéskaïa i Tyéplovosnaïa Tyaga, janvier, p. 1.

ESERINE (A.E.) et RYÉMYÉNNIKOV (S.S.). — **Passage à la journée de travail de sept heures** par les travailleurs des Chemins de fer soviétiques. (2 000 mots.)

1960 **621** .335 = 491 .7

Eléktritchéskaïa i Tyéplovosnaïa Tyaga, janvier, p. 23.

KHVOROSTYANKO (O.M.). — **Signalisation du patinage des essieux des locomotives électriques.** (1 200 mots & fig.)

1960 **621** .332 = 491 .7

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1960 **625** .285 = 491 .7

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1960 **621** .33 = 491 .7

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1960 **621** .333 = 491 .7

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1960 **625** .285 = 491 .7

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1960 **625** .285 = 491 .7

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1960 621 .33 = 491 .7
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1960 621 .33 = 491 .7
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1960 621 .33 = 491 .7
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1960 625 .17 = 491 .7
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1960 625 .143 .4 = 491 .7
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1960 625 .17 = 491 .7
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1960 625 .22 = 491 .7
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1960 625 .122 = 491 .7
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1960 625 .145 = 491 .7
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1960 625 .142 .4 = 491 .7
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1960 625 .145 = 491 .7
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1960 625 .143 .4 = 491 .7
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1960 621 .89 = 491 .7
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1960 621 .332 = 491 .7
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1960 621 .431 .72 = 491 .7
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1960 625 .282 = 491 .7
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1960 625 .282 = 491 .7
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1960 625 .241 = 491 .7
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1960 625 .143 .3 = 491 .7
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1960 656 .222 .4 = 491 .7
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1960 625 .285 = 491 .7
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In Czech. (= 91 .886).

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1961 624 = 91 .886
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M. Weissenbruch & Co., Ltd., Printer to the King, 40, rue de l'Orphelinat, Bruxelles 7.

M. WEISSENBRUCH & Co. Ltd.
Printer to the King
(Manag. Dir. : P. de Weissenbruch,
238, chaussée de Vleurgat, XL)

Edit. responsible : P. Ghilain

PRINTED IN BELGIUM